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ARTIFICIAL FUEL MAKING IN EUROPE.

By ROBERT GRIMSHAW, PH.D.

The "briquette" or block of compressed coal, as generally used in Europe, is composed of fine coal dust, with a "bond" or cementing substance of pitch. This fine coal, often of different kinds, as fatty or poor coal, lignite, etc., comes to the briquette factory sometimes washed, sometimes unwashed; and containing a certain proportion of ash; and the mixture of these various kinds, in proportions determined beforehand, or even varying during the course of manufacture, gives a fuel suited to the needs of various industries.

The pitch is the residue of distillation of coal tars; it is employed in the solid state, broken in particles about the size of those of the coal it is to agglomerate, and it acquires its cementing properties at a temperature of about 80° to 100°C. (176° to 212°F.).

Before speaking of the briquette machine proper, it will be well to describe rapidly the successive operations entering into the manufacture of compressed fuel, as carried on in Europe, and the auxiliary machinery used therein.

The pitch is broken (often indeed, pulverized); then the different kinds of fine coal are weighed and proportioned; and all, coals and

pitch, are immediately mixed—and in some establishments reduced at the same time to a homogeneous powder.

This mixture is gradually brought by steam jackets or jets to the temperature necessary for the agglomeration to take place, is next put into a mould and highly compressed, then extracted from the mould and shipped.

All these operations are done mechanically (although at the celebrated establishment of Monsieur Decauville *ainé*, at Petit Bourg, Seine et Oise, the moulding is done by a hand tamper, as the blocks are small, are not subjected to a rough usage and are used at once at the place of manufacture). The workman has but to superintend the lubrication and general working of the machines.

The machines are:

(1). *The pitch mill;* about like an immense coffee-mill, and composed of two truncated cones of cast iron, one solid, the other hollow; the latter fixed, the former movable, and both armed with projections or teeth, which break, between them, the pieces of hard pitch. The broken pieces are, of course, of a degree of fineness depending upon the distance between the two cones, this being adjustable.

In some establishments a complete pulverization is required; and then the pitch passes from the conical mill into a "Carr" disintegrator. This machine is a very well known concussion disintegrator, unnecessary to describe here. There are modifications of it made in this country, which should answer equally well.

The proportioning of the pitch is done in a *measurer*—a cast-iron cylinder box having a horizontal axis, and partially closed at one end, while open at the other; in this there turns, on the same axis, an endless screw of cast-iron, taking up the material entering by the closed end and pushing it out at the other. This box is surmounted by a hopper kept full of material; and it is easy to see how the quantity of pitch distributed at each revolution of the screw corresponds with a constant volume, depending on the diameter and the pitch of this screw. Belts and conical pulleys give different speeds, and thus enable the quantity and proportion of pitch to be changed, even while the machine is in motion.

The various kinds of coal are weighed out in proper proportions, and mixed in a special measurer; so that the coal and the pitch leave their respective measurers in suitable proportions, and arrive, by sheet-iron troughs, in the hopper of a Carr disintegrator of great diameter,

which turns at a moderate speed, and effects an intimate mixture of the materials, without pulverizing them too much. In small establishments the mixture is effected in cylindrical sheet-iron hoppers in which the material is pushed by arms fixed on an axis of rotation, and approximating in their arrangement and effect the action of a screw.

The products arrive, mixed, in a trough; and a belt and bucket elevator, or a "*noria*," takes them up and discharges them into the mixer of the compressor, or the briquette machine proper.

It is also by means of endless chains that the coal and the pitch are taken from each of the preceding apparatus to the one following, when these are installed on the same level; but these organs can be suppressed by so arranging the establishment, as in a sugar refinery, that the materials descend by gravity in successive cascades, as it were.

The briquette machine of the "Société Nouvelle des Forges et Chantiers de la Méditerranée" is shown in two sections, in Fig. 1.* It is a modification of the Mazeline and Cody compressing machine, well known in Europe in this industry. By the Patent Office classification it would, as now built, be considered as a duplex hydraulic machine, with horizontal mould-tables, continuous moulding and successive production.

It differs from the old type of machine—

1st. In consisting of two separate machines, which can be worked either or both at will, thus permitting one to work at normal belt speeds on half production.

2d. In employing hydraulic pressure. Thus, while in the Mazeline machines the compression is by steam pistons acting on a lever, and reaches a maximum of 90 kilogrammes per square centimetre (say 1200 lbs. per square inch) of horizontal section of the briquette—it varies in the new machine from 100 to 300 kilogrammes per square centimetre of the same section, and without recourse, as we shall see later, to the special pumps, accumulators, etc., which accompany hydraulic machinery of all kinds.

This agglomerating machine consists of:

1st. A *mixer A*. This is a large vertical wrought-iron cylinder in which the materials are brought gradually to a temperature suitable for agglomeration. It is composed of a double envelope in which circulates steam, which keeps the walls at a high temperature. On the same axis, as the cylinder turns continuously, a vertical shaft, armed with

* Taken from *Engineering*, November 8th, 1878.

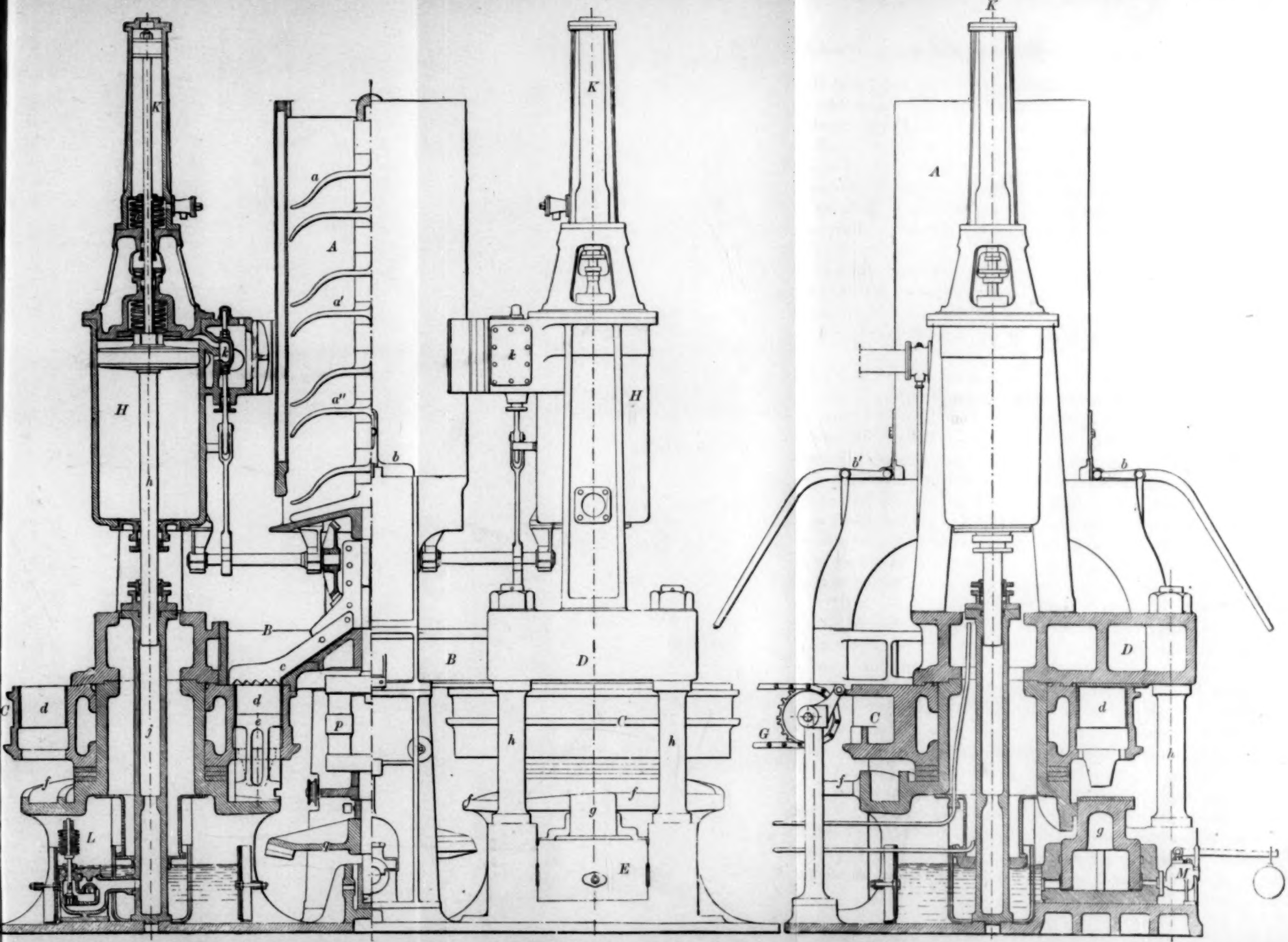
blades, *aa*, which divide the materials, mix them and knead them. Jets of steam are let in at the same time by openings shaped like rose sprinklers, and so placed on the walls as to surround the materials on all sides during the mixing, and to heat them by giving up all the very considerable heat (530 calories). When the material appears sufficiently hot or agglomerant (which the workman can readily see by taking some in a shovel and pressing it with his hands), he opens two doors, *bb*, in the lower side, and the material falls into the distributing apparatus.

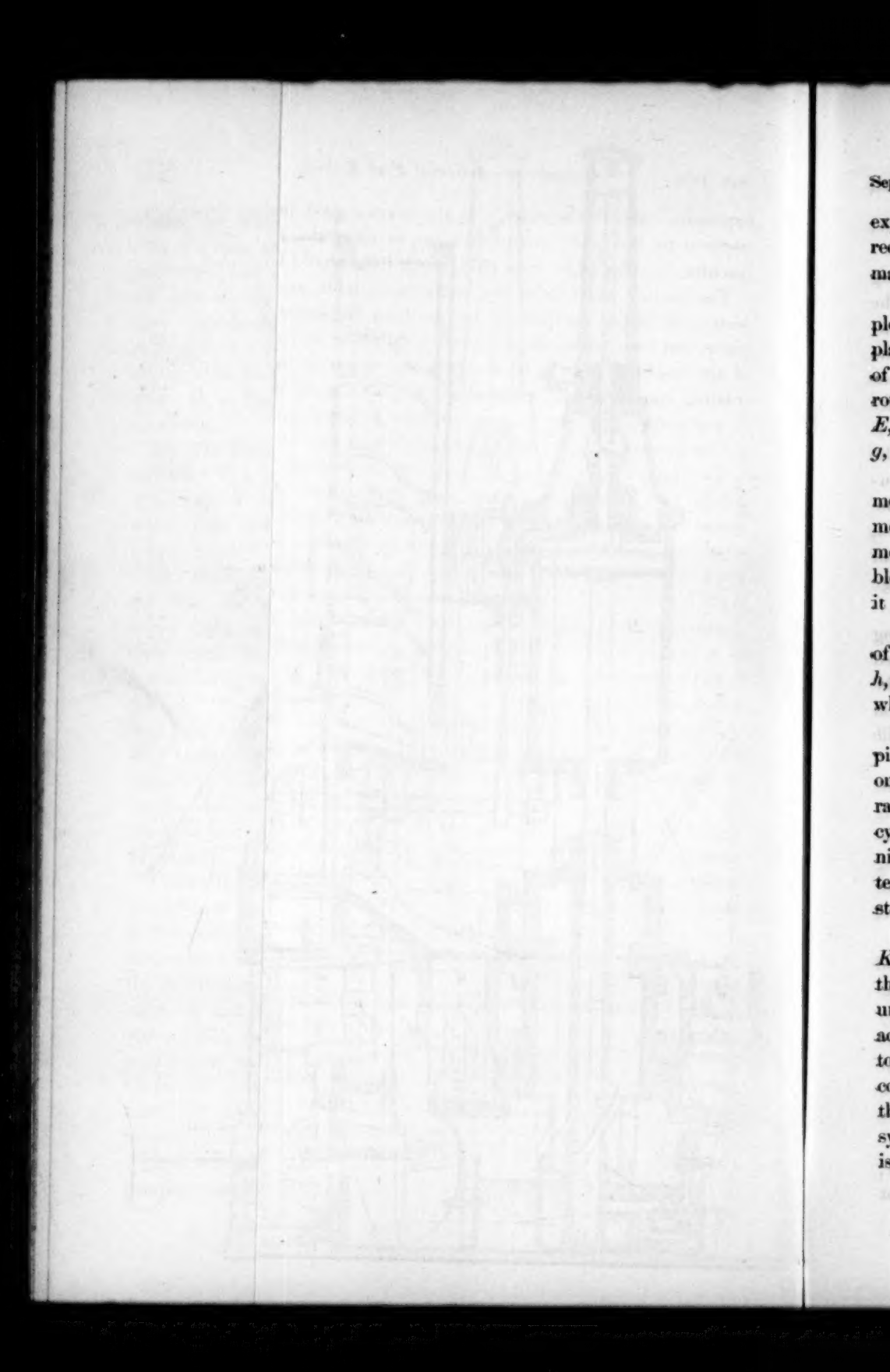
2d. *The Distributor.* This serves to distribute the paste into the moulds. It is composed of a cast-iron chamber, in which turns a rake or scraper, of which the arms *c* sweep the material into the moulds, which pass under the distributor and are there completely and uniformly filled.

3d. *Moulding and Discharging Apparatus.*—One on each side of the filler, and under it, are two rotating "mould-tables," which are heavy disks or plates of cast-iron, bearing on their plane faces, near their circumferences, a circle of angular recesses, faced with steel and corresponding to the form and dimensions of the block or "briquette" desired. These mould-tables have an intermittent motion upon a vertical axis, forming part of the bed-plate of the machine, and carrying with them rectangular compressing blocks or pistons placed in the recesses or moulds. These blocks rest upon and slide on horizontal, circular inclined planes, *f*, which form part of the foundation of the machine, and which give to the blocks a rising and falling motion in the moulds.

Following one of the moulds during a revolution, we note that the mould-table is stopped when each mould is under the distributor; and in this position of mould the piston is at the bottom of its course, and resting on a horizontal plane. The material, pushed by the scraper of the distributor, fills the mould completely. The rotating mould-table starts off and then stops—the mould is still under the distributor; the piston block has slid along the horizontal part of the track, in case the mould were not perfectly filled at the first stoppage, the filling continues and is surely finished. At the next movement of the mould-table, the mould passes under a compression surface, *D*, the block mounts the inclined plane and thus lightly compresses the paste. This "initial compression" is highly advantageous, bringing the paste to a compact condition, and in the case of moist coals (most coals are moist)

Fig. 1.





expressing most of the water. It also saves a good deal of the power required for the heavy compression, as in using the full force of the machine, to effect light work only, much force would be wasted.

The mould rests under the compression-table, and the block completes the initial compresson by finishing the ascent of the inclined plane, and then passes on to a horizontal plane or track on the level of the hydraulic press. In the next movement of the intermittently rotating mould-table the piston-block passes under the press or ram, *E*, and during the next time of stoppage is forced in by the plunger, *g*, thus powerfully compressing and agglomerating the paste.

The intermittent movement of the mould-table continuing, the mould comes from under the compression plate, the block piston mounts a second inclined plane and raises the finished briquette in the mould; so that by the time the table has made a semi-rotation the block is entirely free from the mould, and a "mechanical hand" takes it off the table and puts it on an endless chain, *G*, to be carried away.

4th. *The Compressor.* This essential part of the machine consists of a compression plate *D*, held by strong wrought-iron pillars or bolts, *h*, to the foundation plate and to the steam and hydraulic cylinders which produce the compression.

The cylinder *H*, above the compression table is a steam cylinder, its piston rod, *h*, serving as the plunger of a hydraulic pump, *I*, resting on the bed-plate. In communication with the pump is the hydraulic ram or press, *E*. Above the steam cylinder and on the same axis is a cylinder of lesser diameter, *K*, having its lower end always in communication with the steam supply pipe, so that there is a constant pressure tending to keep the steam and pump pistons at the upper end of their stroke, and the press-ram at lower course.

The steam cylinder is supplied with a steam chest and a slide-valve, *K*, actuated by an eccentric, having a motion proportioned to that of the intermittently rotating mould-table. As each mould-block stops under the press the slide-valve opens the admission port, and the steam, acting on the upper face of the piston, drives the steam and pump pistons down, and the water pressure transmitted to the ram causes the compression. The slide-valve then shuts the steam ports and opens the exhaust port; the piston of the small steam cylinder raises the system to its first position. Between the pump and the hydraulic press is a valve box, *L*, containing two clappet valves—one, *l*, held in its

seat by adjustable springs, and the other, *m*, able to lift freely and let the water return.

The water forced by the pump lifts the spring clappet before acting on the press, so that in case the distribution of the paste in the moulds is stopped or incomplete, and in consequence the effect of compression is suppressed or reduced, the resistance experienced by the water in lifting the clappet prevents too rapid a movement of the pistons and plungers from causing shocks. The return valve permits the water to pass freely from the press to the pump in the next movement. It is easy to understand that this disposition renders the movements of the organs of compression independent, in a great measure, of the regularity of distribution of the materials in the moulds. In case the pistons arrive at the end of their stroke with some considerable speed, as always takes place at the upper end of the stroke, their momentum is taken up by spring buffers, *n*, *o*, in the upper part of the large steam cylinder and the lower part of the little one.

Another part of the compressor is a valve box *M*, communicating with a water tank and containing a safety valve held by a weighted lever, and which valve is lifted when the pressure of the water in the hydraulic press passes any given limit. There is a second or suction valve, which allows water to pass from this tank into the hydraulic pipes to compensate for losses.

5th. *Organs of Movement or Driving Parts.* The intermittent motion of the rotating mould tables is produced by two pawls acting on cast-iron teeth on the crown of the mould tables and corresponding with the moulds; these pawls are actuated by the connecting rods of a crank shaft *p* so that each turn of the axis causes motion of one table and rest in the other. The crank shaft is driven by bevel wheels *q* and a pulley.

The auxiliary apparatus have (as has the main machine) fast and loose pulleys and proper striking gear, and they receive motion from the main driving shaft of the factory. All the transmission is by means of belts, and the tension and the belt lacings or fastenings are arranged so as not to exceed in strength a certain limit; so in case the apparatus is stopped by the presence of a foreign body in the coal or in the pitch, the belt breaks or slips and no damage is done. There are of course necessary the suitable boilers and driving engines.

I gave above the degree of compression which could be obtained; here is a table of the production for twenty-four hours of the different

sizes of this apparatus, the sizes being named after the weight of the blocks produced. It is not very necessary to remind one that the single machine has but one mould table.

Size of machine or Weight of blocks.		Production in 24 hours.	
		Single.	Double.
10· kilogrammes	= 22· lbs.	290 tons.	580 tons.
5· "	= 1·1 "	160 "	320 "
2·5 "	= 0·55 "	86 "	170 "
1·25 "	= 0·275 "	48 "	96 "

The machine described compresses its own water as required, but it is evident that if it were desired one could utilize a natural head of water or draw the water from an accumulator or from any other source of liquid under pressure. In this way the steam cylinders and the pump are omitted, the hydraulic press being retained and supplied with a distribution chest having a suitable slide valve.

Fig. 2.—Curve of Steam Cylinder.
Scale of pressures, 7 mm. = 1 kilog.

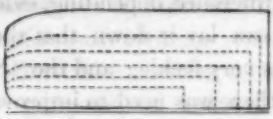


Fig. 4.—Curve of Steam Cylinder.
Scale of pressures, 3·5 mm. = 1 kilog.

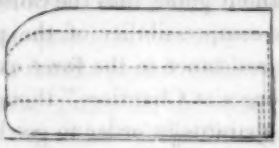


Fig. 3.—Curve of Hydraulic Press.
Scale of pressures, 0·7 mm. = 1 kilog.

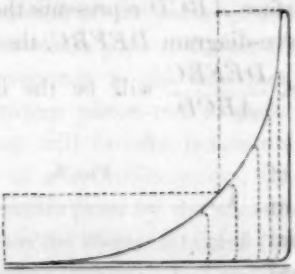
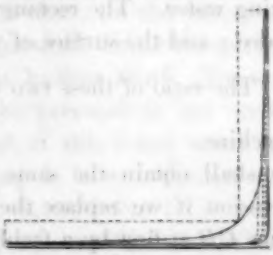


Fig. 5.—Curve of Hydraulic Press.
Scale of pressures, 0·7 mm = 3 kilog.



I shall now give an account of some experiments made for the "Société des Forges et Chantiers," by Mons. Pierre Sigaudy; with the conclusions to which he was led in the direction of economy of steam and of water in the apparatus just described. Mr. Sigaudy has made indicator-curves showing simultaneously the work in the steam cylinder and the resistance in the hydraulic press.

Figs. 2 and 3 show a series of mean curves obtained with a paste

and general conditions giving good products; and the dotted lines show curves sensibly approaching those obtained with feebler pressures, but on the same paste.

Figs. 4 and 5, as well as the dotted lines, show a second series of curves obtained with a "leaner" paste, that is to say one containing less pitch, and, in consequence, requiring more pressure.

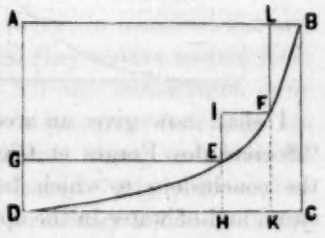
The working pressure is proportional to the rectangular surface 2 and 4, and the resistance to the surface of the curves of 3 and 5. It is easy to comprehend that on the scale of the curves 3 and 5 the working forces could be represented by rectangles having for sides the maximum abscissas and ordinates of the curves; admitting what is theoretically exact and sufficiently verified in practice, that at the end of the stroke the total pressure in the steam cylinder and in the hydraulic press are in inverse proportion to the space traversed.

The general appearance of the two curves is the same; but the laws of the variations of pressure are different.

Without going into the cause of this difference, depending, evidently, on the compressibility of the paste, we can lay it down that the ratio of the resistance to the force expended is very feeble; and the "Société des Forges et Chantiers" thought that there was need to improve their new apparatus in order to get better economic results.

In studying the problem from a general point of view, let *DC*, Fig. 6, be the stroke of the hydraulic press; and *CB* the constant pressure of the inflowing water. The rectangular surface *ABCD* represents the work expended; and the surface of the curve-diagram *DEFBC*, the resistance. The ratio of these two surfaces, $\frac{DEFBC}{ABCD}$ will be the duty of the machine.

Fig. 6.



We shall obtain the same work of compression if we replace the constant pressure *CB* at first by a feebler initial pressure *DG*, then when the ram has traveled the space *DH*, by a second pressure *HI*, and finally, after the course *DK*, by a pressure *KL*. The work expended in this case will be equal to the surface of the three rectangles *DGEH*, *HIFK* and *KLBC*; and it is easy to understand that in this way the duty of the machine will be greatly increased,

and would be still further increased by increasing the number of successive pressures.

The mechanical arrangement by which this is proposed to be effected by the "Société des Forges et Chantiers" gives two successive and increasing hydraulic pressures, independent of the initial wedge-pressure given by means of the inclined plane.

The economy of steam resulting from this arrangement is considerable. In making the calculations from the curves, based on a pressure of 50 kilogrammes per square centimetre, the weight expended per stroke of piston is $\frac{4}{5}$ that to obtain the same result with a single pressure; and for a pressure of 100 kilogrammes per square centimetre (say 1375 lbs. per square inch), the expenditure is reduced to 20 per cent. of that indicated by curve 4; that is to say, a mean economy of $\frac{3}{5}$ the steam.

The new machine is represented in section and elevation in Figs. 7 and 8. In comparing it with Fig. 1, we see that the *two* steam cylinders (the compression cylinder and the auxiliary steam cylinder) are replaced by a single steam cylinder *A*, of which the piston carries an expansion joint *a*, and which receives the steam by a double ported slide valve *b*. The plunger pump is replaced by a piston pump *B*, having a valve chamber *C*. Finally, for the buffers in the steam cylinders, there is substituted a single box containing a rubber block *D*, in full sight and controlable while the machine is running.

The section of the pump piston is such that with the steam acting above the steam piston, the pressure of the water under the pump piston corresponds to the first rectangle in broken lines. The section of the pump piston-rod is such that the pressure of the water in the pump will be the maximum desired, if this steam acted as the plunger of a hydraulic pump. This pump is in communication with the hydraulic press by the passage *C*.

Suppose the steam admitted by the upper port of the slide valve, the pump piston descends and compresses water in the press at the first pressure. At the same time the space which would otherwise be left void above the pump piston, is kept full by means of a valve *d* in communication with a supply tank.

As soon as the resistance of the press passes what we should call the first pressure (that is, the first *hydraulic* pressure) on the paste, the valve *e*, held by a suitably adjusted spring, opens; the water, under pressure (I object to the use of the expression *compressed* water) passes

FIG. 7.

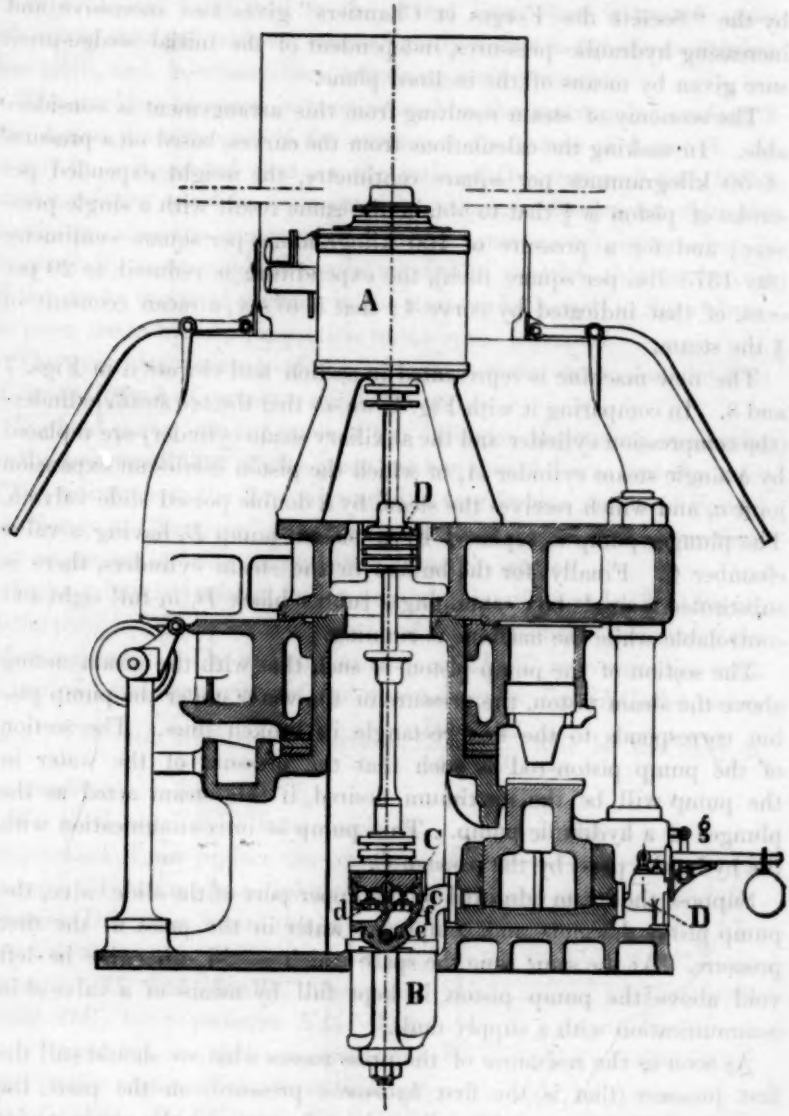
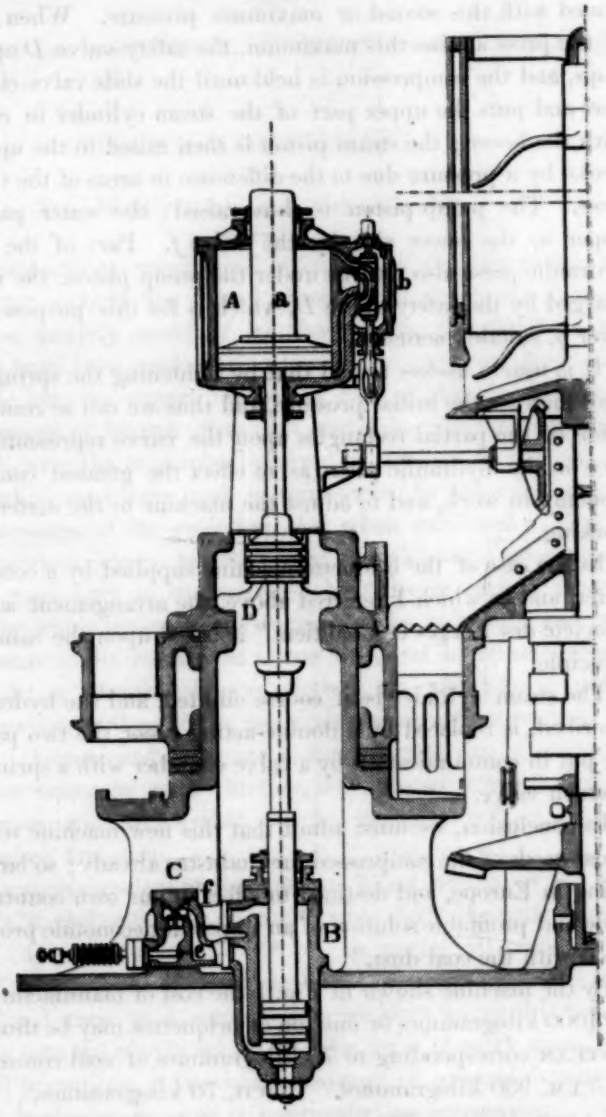


Fig. 8.



in part from the other side of the piston, shuts the suction valve *d*, and we have the conditions of a hydraulic pump having a plunger of a diameter equal to that of the piston-rod. The compression is thus continued with this second or maximum pressure. When the resistance of the press attains this maximum, the safety-valve *D* opens, the press stops, and the compression is held until the slide valve closes the steam port and puts the upper part of the steam cylinder in communication with the lower; the steam piston is then raised to the upper end of its stroke by a pressure due to the difference in areas of the two piston surfaces. The pump piston is thus raised; the water passes from the upper to the lower side by the valve *f*. Part of the water in the hydraulic press also returns under the pump piston, the rest being discharged by the safety-valve *D*, which is for this purpose raised by the lever *g*, suitably actuated.

It is nearly useless to add that by tightening the spring of the valve *e* we increase the initial pressure, and thus we can so control the disposition of the partial rectangles upon the curve representing the resistance on the hydraulic press, as to effect the greatest convenience and economy in work, and to adjust the machine to the material it may be working.

In the case of the briquette machine supplied by a constant head of water, and to which I referred above, the arrangement adopted by the "Société des Forges et Chantiers" is based upon the same mechanical principle.

The steam cylinder is of course omitted, and the hydraulic press, as described, is replaced by a double-acting press, the two parts of which are put in communication by a valve chamber with a spring poppet and a return valve.

In conclusion, we must admit that this new machine responds to the actual needs of the compressed fuel industry already; so large and flourishing in Europe, and destined to effect in our own country the practicable and profitable solution of an important economic problem, "What to do with the coal dust."

By the machine shown in Fig. 1 the cost of manufacture, in France, per 1000 kilogrammes or one ton of briquettes may be thus distributed:

STEAM corresponding to 70 kilogrammes of coal consumed.

CULM, 930 kilogrammes. PITCH, 70 kilogrammes.

LABOR, 1f.50 = 30 cents; in time, 3 hours.

LUBRICATION, f0.50 = 10 cents.

The above mentioned items are greatly lessened in the machine shown in Figs 7 and 8.

WEAR AND TEAR and MAINTENANCE, 7 per cent. per year on cost of plant.

INTEREST, 5 per cent. annually on cost of plant. (For America say 6 per cent.)

THE FLEXIBLE SHAFT.

By GEORGE BURNHAM, JR.

There is probably no mechanical invention of the last decade that has seemed, not only to the casual observer but also to the mechanician, to be so entirely novel in its character as the flexible shaft. Great strides have been made during this period, it is true, in all kinds of machinery, but the expert recognizes most of them as extensions and developments of known ideas and methods. So radically different, however, were the principles involved in this tool from those usually employed in machinery, and so unobserved by the world at large had been the stages of its evolution, that when exhibited at the Centennial Exhibition every beholder was struck with astonishment. Almost all machinery is characterized by fixity in certain planes of motion. The whole value of the turning lathe is conditioned upon the maintenance of its centres in a true line, and in all reciprocating machine tools, as planers, shapers, slotters, etc., and also in milling tools, the moving portions of the mechanism are confined to fixed lines and planes. Accustomed as we are to this characteristic of machinery, a device that transmits rotary motion, not through straight lines but through curves, and curves that may be varied at will, is naturally surprising when first seen.

The Paris correspondent of the London *Times*, writing of the Exhibition of 1878, and referring to the flexible shaft, correctly expresses this feeling when he says " * * * it upsets all one's ideas of rigidity. Pharaoh himself could not have been more surprised at seeing Moses' rod turn to a serpent than we were to see this rope-like affair eating into the planks set on all sides for it to work upon." And yet, like all inventions, it has had its history of gradual development from crude beginning to more or less perfect consummation.

The first "flexible shaft" was simply a coil of wire. This was used as a universal joint in sheep-shearing machines, dental engines, and

other light power machines. In the reports of the Paris Exhibition of 1867, however, will be found a description of a Belgian windmill involving a shaft of this character, made of rectangular steel bar, about $\frac{1}{4} \times 1\frac{1}{4}''$, coiled into a spiral spring, some six inches in diameter. The limitations of this form of the device are quite evident. The flexibility was obtained at a great sacrifice of strength, to compensate for which the coil had to be made of inconveniently large diameter, about six inches, as above stated, making it equal to a solid shaft of one and one-third inches diameter only.

It was soon found that the angle of torsion was so great in the single coil shaft that it could not be used where positive motion was desirable. One of the first attempts to correct this defect was made in January, 1865, a patent of that date,* describing a shaft made of a coil of wire wound on a centre of "gum elastic or rolled canvas, or other flexible material." This, of course, was an improvement over the first form only to the extent of the resistance to compression offered by the filling material. The next step, one of great importance, was the substitution of two concentric coils, wound in opposite directions, for the single coil heretofore employed.† By this arrangement the tendency of the outer coil to contract is met by an equal effort of the inner coil to *expand*, while the greater metal section of course increases the strength of the shaft.

It will be seen, however, that some of the flexibility is lost by this construction, since it requires more effort to bend two coils than one.

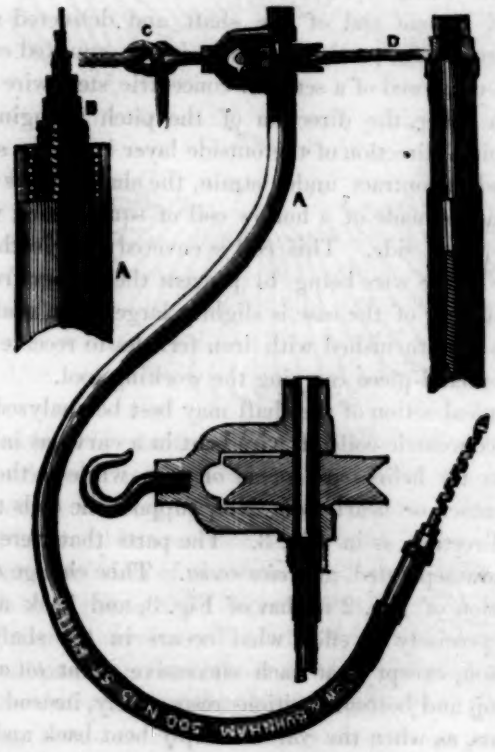
Up to, and including this stage of its progress, there existed one vital fault in the shaft that confined its use to light power machines. If, in any of the forms heretofore described, the length be over a certain number of diameters, its power-transmitting capacity becomes extremely limited on account of its liability to kink or twist out of line and double up into twisted loops. The effect is easily seen by taking a short piece of rope, fastening one end and twisting the other. The rigidity of the rope will be found to increase to a certain limit, when at some point it will suddenly twist into a loop. Shafts of this form, also, if run at a speed of more than three or four hundred revolutions per minute, vibrate in a very curious manner, the shaft divid-

* Thos. Welham, Jan. 31, 1865. Improvement in Universal Shafting.

† Greene V. Black. Patent of Aug. 8, 1871. Improvement in Universal Joints for Shaft Couplings. The title of this patent indicates the restricted use of the principle at that time.

ing into equidistant nodes like the strings of a musical instrument. This action is usually so marked as to interfere with the proper functions of the working tool, giving it a tremulous motion that is difficult or impossible to control. These defects were finally overcome by enclosing the revolving shaft in a flexible *stationary* sheath or case, and at the same time the carrying power of the shaft itself was increased by making it solid all the way through, in the sense that a wire rope is solid.* The effect of the case or sheath (a hollow coil of wire covered with leather or other flexible material) was to give the revolving core an indefinite number of bearings, in whatever direction it might be placed, thus entirely preventing the tendencies of the naked core to kink and vibrate as described above.

FIG. 1.



Upon reflection it will be seen that this is simply an extension of

* Nelson Stow. Patent of Aug. 6, 1872. Improvement in Flexible Shafts.

the principle we employ with rigid shafting that is too light to carry its load without vibration; we *increase the number of bearings*, and thus break the shaft into shorter sections. The increased metal section of the "solid" shaft, while enhancing its strength, of course again diminished the flexibility. Since, however, the action of the case permitted the use of much longer shafts than were practicable without it, this loss of flexibility was of comparatively small importance, as the same amount of total curvature could be obtained by making the curve more gradual and increasing its length.

Thus, a shaft $\frac{3}{8}$ in. diam. (of core), and six feet long, will work in a complete circle or total angle of 360 degrees.

*As now constructed the flexible shaft is made up of a *core*, a *case*, and appropriate fittings by which the two are joined, and rotary motion communicated to one end of the shaft and delivered at the other. These parts are shown, partly in section, in the annexed cut.

The core is composed of a series of concentric steel wire coils wound hard on each other, the direction of the pitch changing with each layer. The pitch direction of the outside layer is always such that the latter will tend to contract under strain, the shaft always running one way. The case is made of a hollow coil of square wire, with a slight groove on the outer side. This coil is covered with leather, the office of the groove in the wire being to prevent the leather from slipping. The inside diameter of the case is slightly larger than that of the core, and the ends are furnished with iron ferrules to receive the driving pulley and the hand-piece carrying the working tool.

The mechanical action of the shaft may best be analyzed as follows: Imagine two concentric coils of wire bent in a curve as in Fig. 2. On the outer curve the helices are spread or open, while on the inner curve they are in contact or nearly so. Now suppose the coils to be bent in the opposite direction, as in Fig. 3. The parts that were formerly in contact are now separated, and *vice versa*. This change of curvature from the position of Fig. 2 to that of Fig. 3, and back again to that of Fig. 2, is precisely in effect what occurs in the shaft during one entire revolution, except that each successive point on a given helix occupies the top and bottom positions respectively, instead of only two meridian points, as when the coil is simply bent back and forth. At every moment, then, some point in every helix is undergoing a slight

*The Stow Flexible Shaft Co., Limited, 500 N. 15th st., Philadelphia, are the sole makers of the flexible shaft for other than dental purposes.

torsion, whose amount depends upon the diameter of the particular coil in which it is situated, and the curvature of the shaft itself. As long as this torsional strain is kept within the limit of elasticity of the material the shaft will revolve indefinitely without detriment; but should this limit be exceeded the shaft will rapidly give way. If a piece of core be mounted in bearings, and *curved excessively*, it will

FIG. 2.

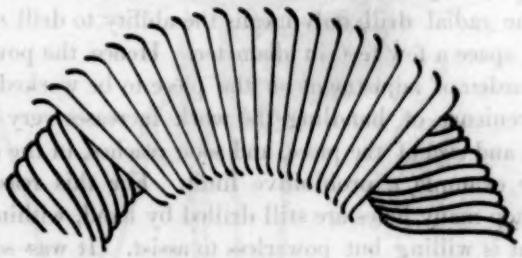


FIG. 3.

soon begin to heat, if set in motion, and will finally break. In practice this contingency is provided for by making the case sufficiently rigid to prevent bending beyond the safe limit. Referring again to Figs. 2 and 3, it will be seen that there must be some slight rubbing action between the wires of the inner and outer coils. The effect of this action is so slight as to be imperceptible, even in shafts that have been a long time in service. The other frictional elements are those common to all machines, viz., the wear of the journals and their bearings, and the wear of the outer layer of the core at points of contact with the case.

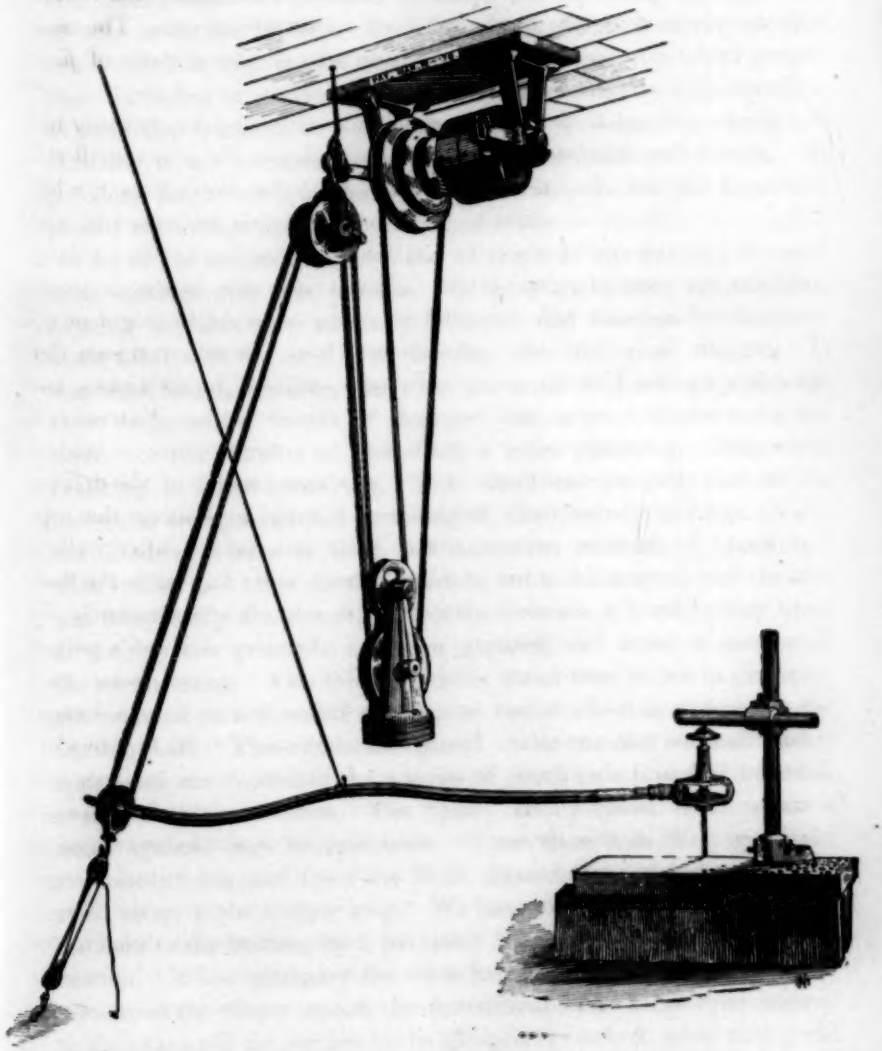
Since the flexible shaft is not a special tool for a particular purpose, but a connecting link between a given power source and a multitude of tools, its uses are very varied. The first successful application of this

tool was in dentistry, the necessities of the dentist being, in fact, its *raison d'être.* It is needless here to descant upon its use in this line, however, as nearly every one who has need of the dentist's services is familiar with the dental engine and its power of shortening the time of painful operations on the teeth. In heavier operations the leading place occupied by the shaft has been in metal drilling. The usual power drills are no exception to the general rule stated above of *fixity in certain planes of motion.**

Even the radial drill only means the ability to drill *vertically* in a cylindrical space a few feet in diameter. Hence the power drill still puts the burden of adjustment on the piece to be worked itself, while the inconvenience of handling the work increases very rapidly with the weight and size of the piece, and soon reaches, in the case of large boilers, for example, a prohibitive limit. For this reason, in every machine shop many holes are still drilled by hand, within sight of the engine, that is willing but powerless to assist. It was soon seen that the flexible shaft would prove a valuable adjunct in such cases, and appropriate tools were made to meet the requirements. Extension is obtained, not by increasing the length of the shaft, which is seldom over eight feet in length, but by increasing the length of the driving rope. Varying directions are obtained; first, by leading the rope through a "transfer pulley," which is simply a pair of idler pulleys mounted one over the other in a light frame, and attached to the floor directly under the counter-shaft. Second, and more conveniently, by a device styled a "roundabout transfer," consisting, first, of a pair of idler pulleys, mounted one over the other in a weighted frame, and, second, of a pair of pulleys in a swivel frame, attached to a hanger adjoining the countershaft. The driving ropes lead from the counter-shaft down to the weighted frame, then over the swivel pulleys, and thence to the pulley on the flexible shaft, as shown in the accompanying cut. With this device the shaft and its drill may be carried at will to any part of the shop, the only limits being the length of rope used and the height of rise and fall at command for the weighted frame. Since both the leading and following ropes are carried down to the weighted frame, and thence over the swivel pulleys, the combinations form in effect a system of one *fixed* and one *movable* pulley; hence

* A notable exception to this is the Thorne Portable Drill, described in the JOURNAL of November, 1871.

FIG. 4.



the available extension of the drill is *twice* the rise of the weighted frame, an attribute of considerable importance in low-studded rooms.

The shaft is also used for grinding and polishing metal work with emery wheels, wood, walrus hide and felt wheels, coated with emery, etc. Attachments are provided by which the wheel may be used either on edge or on the flat side. In solid wheels the limit to the size that can be used on edge is soon reached, as the reaction of a wheel greater than six inches in diameter, running at the necessarily high speed, is so great that it cannot be held to the work. With smaller wheels this difficulty is not encountered, nor does it occur with soft wheels. In polishing bright work, as show-case frames, etc., the familiar rag-wheel is used with rouge or other polishing powders.

One of the earliest suggested uses of this tool was cleaning the sand from castings with wire brushes. In the effort to carry out this idea, existing methods were naturally followed, and circular brushes were made filled with flat steel wire bristles, after the usual manner. It was soon found, however, that what answered well enough under the slow, reciprocating motion of the hand, was an utter failure under the rapid, circular motion of the shaft, a large percentage of the wires breaking in a few hours' use. This result was probably due to the molecular changes induced by the rapid vibration of the wires. Various kinds of wire were tried and numerous methods of "packing" with rubber and other elastic materials, but without avail, and the idea was temporarily abandoned. Recently, however, a brush, acting upon an entirely new principle, has been invented, and seems to answer all the requirements. Two thin iron disks, about four inches in diameter, are mounted on a threaded spindle, one end of which is attached to the flexible shaft. These disks are placed about two and one-half inches apart, and are connected by a series of small rods placed at intervals around the circumference. The "hub" thus prepared is not unlike a small squirrel cage in appearance. Upon these rods short wire links are loosely hung, and from the links depend wires of ordinary round steel, about three inches long. We have thus a brush whose bristles are held to the backing by a free joint instead of the usual rigid connection. When stationary the wires hang perfectly limp, but when in motion, at the proper speed, the centrifugal force keeps them normal to the axis until the surface to be cleaned is reached, when they yield and drag across it. It is found in practice that the brush so constructed is as efficient as the stiff brush, and is much more pliable, adapting

itself better to irregularities in the surface, while the wear is entirely confined to the joints and gradual abrasion of the ends of the wires. Wheels for sand-papering wood work, made upon the same principle, have been tried and found very effective. The sand-paper is cut into circular disks, which are strung on an appropriate mandril, each disk being separated from its neighbor by a small washer. This arrangement gives the tool great flexibility and at the same time does away with the inconvenience of frequently renewing the cutting surface inherent in the plan of wooden centres covered with sand-paper, since it is effective until worn nearly to the centre.

The shaft has also been found of great utility in stone working operations. The horizontal "lap" that has so greatly expedited the surfacing of small pieces is of no avail for large blocks, on account of their great weight and size; but the shaft enables the lap, on a small scale, to be carried to the work itself. In the apparatus constructed for this purpose, either turned iron disks or frames carrying concentric rings made of zinc, are attached to geared machines (similar to the drill press) on the end of the shaft. The grinding material is sand or emery with water.

The following tables give the results of a series of tests and experiments made in August, 1877. Recent improvements in the make up of the shaft would doubtless change these figures somewhat.

TABLE No. 1.

1	2	3	4	5
Selling No. of Shaft.	Length of Specimen.	Diam. of Specimen.	Proof Strain in lbs. at 1 foot from centre.	Angle at Elastic Limit.
0	3	9·32	4·018	77·
2	3	3·8	9·715	30·3
3	3	1·2	21·109	20·6
4	3	5·8	41·346	29·
6	3	15·16	119·832	10·7

The figures in Table No. 1 are from a series of actual tests made at the Stevens Institute of Technology, Hoboken, N. J.

By Proof Strain is meant the maximum weight which the specimen carried (at a distance of one foot from the centre), without giving the material a permanent set.

The tests in Table No. 2 were made with an Emerson Dynamometer.

TABLE No. 2.

1	2	3	4	5	6
No. of Test.	Selling No.	Speed of Shaft.	NATURE OF WORK.	Work done ft. lbs.	REMARKS.
1	4	1300	$\frac{1}{2}$ in. Aug. in Pine	36288	Shaft nearly straight.
2	"	"	" "	36288	" bent through $\frac{1}{2}$ circle.
3	"	1050	$\frac{5}{8}$ in. Augur.	34992	" " " $\frac{3}{4}$ "
4	"	"	" "	36288	" " " $1\frac{1}{4}$ "
5	"	700	1 in. Augur.	41472	" nearly straight.
6	"	"	$\frac{3}{4}$ in. drill in cast iron.	33048	Drilled $1\frac{1}{2}$ in. in 2 minutes.
7	"	"	$\frac{1}{2}$ in. Drill.	34992	" $1\frac{1}{2}$ in. in 1 "
8	"	"	$\frac{19}{32}$ in. Drill.	40176	" $\frac{7}{8}$ in. in 1 "
9	6	412	Not Working.	6400	New Shaft. Straight.
10	"	"	$\frac{3}{4}$ in. drill in cast iron.	20480	Drilled 2 in. in $1\frac{1}{2}$ minutes.
11	"	"	1 in. " "	23680	" 1 in. in 1 "
12	"	"	$1\frac{1}{4}$ in. " "	26240	" 1 in. in 1 "
13	"	950	Friction Wheel.	69552	No injurious effect on shaft.

Besides those mentioned above, the shaft has been utilized in many minor operations, as horse and cattle brushing, plate glass cleansing and polishing, morocco finishing, and even in *boot-blacking*. From its position as an intermediate term or connecting link between the working tool and the power source, leading mechanical power into the more intricate ways and remote corners heretofore only approachable by the human arm, it is apparent that manifold applications of the flexible shaft will be made in the future that are not now considered.

ACCIDENTS IN THE COMSTOCK MINES AND THEIR RELATION TO DEEP MINING.

By JOHN A. CHURCH, M.E.

A paper read at the Pittsburgh meeting of the American Institute of Mining Engineers, May, 1879.

Early in the month of August, 1877, a miner in Gold Hill, Nevada, made the unlucky remark that, according to his observation, that month was usually quite free from accidents in the mines. Never was presage wider from the truth. When the month closed twelve mishaps had occurred, killing six and wounding nine persons, and for the rest of that year the Comstock mining communities were kept in a ferment by the frequent occurrence of appalling disasters. There was a real tidal wave of calamity sweeping over the mines, which has not been repeated since, and according to common report was never known before on the Comstock. I was much interested in studying the character of these misfortunes, which also aroused concerted action on the part of the miners, and I have collected a list of the accidents which took place from July, 1877, to May, 1879. The number in this period of twenty-two months is 101, killing immediately 53 persons and wounding 70 others. This list is incomplete in every way. All accidents which did not injure persons are omitted, and there are several which were of a threatening kind but fortunately did no damage to human beings. Probably others have been overlooked which did belong to the category included in my lists. Finally, no effort has been made to ascertain how many of the wounded died of their wounds, and the number of fatal casualties includes only those who died so soon after their injury that their death became a part of the current records of the accident.

Many of these accidents belong to the usual classes of mishaps in mines and will receive no extended discussion. Others are worth examination from their connection with labor in hot mines, deep mining, and other causes intimately dependent on the local conditions of the Comstock. They may all be classified under eight general heads: 1. Falls of rock, timber, etc. 2. Tramming. 3. Effects of heat. 4. Falls of men. 5. Explosions. 6. Hoisting apparatus. 7. Over-

winding. 8. Miscellaneous. The distribution among these groups in each year is shown in the following summary:

	1877 6 mos.	1878	1879 4 mos.
(1.) Casualties due to falls of rock, ice, timber, etc.			
Number of occurrences,	8	7	8
Casualties, fatal,	2	4	3
Casualties, not fatal,	7	4	5
Proportion fatal, 36 per cent.			
(2.) Casualties in tramming.			
Number of occurrences,	4	3	
Casualties, fatal,	1	0	
Casualties, not fatal,	4	3	
Proportion fatal, 12½ per cent.			
(3.) Casualties due to heat.			
Scalding:			
Number of occurrences,	1	2	
Casualties, fatal,	1	1	
Casualties, not fatal,		1	
Proportion fatal, 33 per cent.			
Overheating:			
Number of occurrences,	1	8	
Casualties, fatal,	1	7	
Casualties, not fatal,		3	
Proportion fatal, 73 per cent.			
(4.) Casualties due to falls of men.			
Number of occurrences,	7	7	2
Casualties, fatal,	2	6	2
Casualties, not fatal,	5	1	
Proportion fatal, 62½ per cent.			
(5.) Casualties due to explosions.			
Number of occurrences,	5	6	3
Casualties, fatal,	3	2	5
Casualties, not fatal,	5	6	
Proportion fatal, 71 per cent.			
(6.) Casualties in hoisting.			
Number of occurrences,	4	6	1
Casualties, fatal,	2	3	1
Casualties, not fatal,	2	6	
Proportion fatal, 43 per cent.			

	1877 6 mos.	1878	1879 4 mos.
(7.) Casualties by overwinding.			
Number of occurrences,	1	2	
Casualties, fatal,	1	2	
Casualties, not fatal,	1	1	
Proportion fatal, 60 per cent.			
(8.) Casualties due to miscellaneous causes.			
Number of occurrences,	7	8	
Casualties, fatal,	1	3	
Casualties, not fatal,	10	6	
Proportion fatal, 20 per cent.			
Total occurrences,	38	49	14
Total fatal casualties,	14	28	11
Total casualties not fatal,	34	31	5
Grand total for 22 months:			
Occurrences,	101		
Total casualties,	53		
Casualties, not fatal,	70		
Proportion fatal, 43 per cent.			

This list is not offered as a summary of accidents in the Comstock mines, but merely as an index to the causes which operate there to endanger life. Many of these are common to all mining operations, but others are quite peculiar and deserve timely discussion, for it is supposed that they are likely to increase in force with the deepening of the mines, which is now rapidly progressing.

In the third class, or those casualties which are due to the high temperature of the mines and the rock in which they are opened, we have some of the most singular occurrences known in mining. The injuries by scalding were occasioned entirely by falling into the hot mine waters. Their temperature varies with the locality, but the maximum which I have observed is 156° Fahr., and usually it is considerably below this. This temperature seems to be sufficient to produce serious effects. One miner, who slipped into the Julia water, sinking nearly to his knees, got out so quickly that the water did not have time to enter his shoes, and yet his legs were scalded so severely that the skin came off. The same mine was flooded early in the present year with water which was reported to have a temperature of 158° Fahr., and a miner who, in a fit of absent-mindedness, stepped into it, immersing

himself to the chin, was fatally injured. The water is hot and gaseous, and the unfortunate man who falls in it sinks deeply and probably finds it difficult to regain the surface.

But it is in the effects of work in hot air upon the human frame that the most remarkable casualties are witnessed, and this class is purposely put first among those which are to be discussed, because it seems probable that a considerable proportion of all kinds of accidents in these mines are indirectly due to the heat. The proportion of fatal casualties is larger in this class than in any other, being 73 per cent., and from the peculiar mental effects of the heat it is obvious that it may be and probably is the initiating cause of many mishaps which would under other circumstances be ascribed to culpable blundering.

On the 1900 level of the Gould and Curry mine a drift was run to the southward from the shaft, following the line of the black dyke and lying quite near it. This proved to be one of those hot spots which I have before described to the Institute as a marked peculiarity of the Comstock rocks. As a rule the drifts at this depth have not been above 108° or 110°, and many have been less hot, but this drift has several times been reported to show a temperature of 123°, 126°, and 128° Fahr. Thomas Brown, a miner working in this place, fainted, and when taken to the surface and revived, was found to have completely lost his memory. He could not tell his name or where he lived, and had to be dressed and taken home by his friends. The paper which records the occurrence says: "This sudden loss of memory from overheating is quite common in the mines, but the effect soon disappears and the men are themselves again. This fact furnishes an explanation of how men, who are considered experienced miners, walk off into fatal winzes and chutes, seemingly with deliberate intention."

A frequent accident in these mines is fainting in the shaft while the cage is rising to the surface. The faintness is always felt immediately upon reaching the cooler air a hundred or a hundred and fifty feet from the surface, where there is usually a side draft through some adit. This casualty is so common that a man who has been working in a hot drift is not allowed to go up alone. Long habitude to the heat is no safeguard against this danger, and serious accidents have occurred in this way. The faintness, I believe, is preceded by nausea, but insensibility follows quite suddenly.

Among the minor casualties I have included one which is said to have happened to Mr. Sutro. Being in the Sutro tunnel before it made

connection with the Savage mine, and in an air temperature of 110° Fahr., he went to the air pipe to cool off, and staid there so long that the miners told him to get away from the pipe and let them have air. He did not move, and the account says they tried to stir him up with the handles of their shovels, but he had lost all volition and could not budge. Finally he was put on a car and taken out.

These are the minor effects of the heat. Its graver results are well shown in the following cases of insanity and death:

The first of these, which I introduce with some hesitation, is described by the Virginia *Evening Chronicle* as follows: "At half past nine o'clock Monday morning, March 11th, 1878, a man died at the Caledonia mine in Gold Hill, under peculiar circumstances. The man had been iddle for six months, and was working his first shift in that time, he having gone down this morning at seven o'clock. He was put to work as carman on the 1400 level. At the hour stated he rushed into the station at the 1400 level and told the station-tender that the wheels of his car were smashed all to pieces. The station-tender walked back with him to the car, when it was found all right. The station-tender thereupon saw that something was wrong with the man, and took him to the cooling-off place. There he soon began talking wildly and behaving boisterously, and giving other indications of mental aberration. It was therefore thought best to bring him to the surface. He was firmly lashed to the cage and hoisted up, but on reaching the surface he fainted away and died in a few minutes."

The heat on the 1400 level of the Caledonia is not very great, being about 90° Fahr., and this man's sudden decease may have been due to other causes.

Of the other fatal casualties, one was from cramps, which the account attributes to the heat, but which may have been the result of drinking ice water, and another was from a cold taken while cooling off after being partially overcome by the heat. It is to the drinking of ice water and the comfort of a strong draft that the men resort for recovery from the exhaustion caused by the heat, and though these methods, so contrary to the ordinary rules of hygiene, are put in use several thousand times a day, and usually with impunity, these two instances are proofs that they may be dangerous. The miners consider the draft of cool air safer than drinking copiously of ice water, but when in the mines I choose the latter method to save time, and never felt ill effects from it.

The next case illustrates the violent effects which excessive heat may have upon a person not accustomed to it: "On Friday, October 11th, 1878, John McCauley went to work for the first time in the Imperial mine. He was cautioned against over-exerting himself in the extreme heat of the lower levels. He replied that he thought he was strong enough to stand anything and paid no attention to the advice. At half-past two in the afternoon he was brought to the surface in an unconscious state, and died the next morning at half-past ten o'clock."

Two other cases very similar to this have occurred in the Imperial within a few years. This mine is excavated in one of the hot spots of the Comstock.

The hot drift on the 1900 level of the Gould and Curry is the scene of the most serious of these casualties due to heat. Five men were sent there in June, 1878, to load a donkey pump on a car. The work was so exhausting that when the pump caught on a plank they were not able to move it. They seem to have been in a state of mental confusion, but felt that they could not remain longer. Starting up a winze which connects with the 1700 level one man fell on the way, and the others were afraid to stop to help him, but pressed on, reaching the 1700 in half an hour from the time they left it. They were very confused and nearly speechless, and hardly realized what had occurred. Three men went down to the rescue and found the fallen man still alive. Clearing the pump they got into the car and signalled to hoist, but on the way up the winze the man they had gone to rescue reeled and fell off. The car was stopped at once, but he was jammed between it and the brattice so fast that the others left him and went for help. They all gave out, two half way up, and the other just as he reached the 1700 level, where a friendly hand pulled him up. A new rescue party went down and found two men dead, and the third died soon after. The shift boss reports that "the accident was due solely to the heat, as the air is good enough and pure enough, barring the heat." The winze was not an abandoned one, but in daily use. A heavy volume of steam is reported to rise through it from the 1900 level, the temperature of which, at the time of this accident, is given at 128° Fahr. I gather from the detailed account that the death of the men is possibly attributable to the fact that when the miner fell off the car the latter was stopped in a place that was hotter than the rest of the winze.

It is to be regretted that no adequate studies have been made upon

the precise physiological phenomena presented by death under these circumstances. The legal requirements are satisfied when it is proved that the casualty was due to "heat," but if the theory of heat production in these rocks, which I have advocated before you, is correct, and currents of hot gas, rich in carbonic acid, are pouring through narrow belts of shattered rock, the death of men who are stopped in one of these belts may have a more complex cause.

(4.) The most appalling accident which can occur in mining work, the falling of men down a deep shaft, repeats itself in the Comstock mines with a frequency which, I believe, is unknown elsewhere. Sixteen occurrences of this kind took place in twenty-two months, and ten of the casualties were fatal. There were seven falls in the shaft, six in winzes and one in a chute, and three in the floors. One of these deaths was traceable to the effects of foul air, the lights having gone out and the party being on the cage in retreat from the drift.

These dreadful accidents being more common on the Comstock than in any other mines that I know of, it is important to ascertain whether this frequency is attributable to the heat. In some cases we may answer in the affirmative. When a timberman repairing the upcast shaft of an unusually hot mine falls to the bottom we may fairly conclude that the tendency of blood to the head which the lifting of a heavy weight occasions may have been increased to momentary stupefaction by the heat, steam and gases of the shaft. But though my own impression before examining this subject was that the heat was largely accountable for these mishaps, I am forced, by a study of the casualties in this record, to admit that this is not the most frequent cause of them. If the Comstock miner is more liable than his fellows to this form of accident, it is because he is more often called to work in the shafts after they have been completed.

The Comstock shafts are all sunk in the hanging wall, and the vast excavations which have been made in most of the mines make the settling of this wall inevitable. But besides that, the Comstock rocks are forever moving, swelling and forcing the shafts out of line. No shaft there is in perfectly good condition. Some stand remarkably well, and keep in working order for years, while others require frequent repairs; but from the day they are completed their deterioration is steady, until a general overhauling is necessary. They are timbered in a manner which allows remarkable variation from their original alignment without loss of local support to the ground, and this timber-

ing is rapidly and conveniently readjusted when pushed too far out of line. The work of repair is necessarily dangerous and more hazardous in a hot steaming upcast shaft than in a cool one, and it is to the frequency with which the Comstock miner is called upon to perform this work that the number of falls in the shaft is to be attributed. It is also undeniable that the unfavorable heat conditions may contribute essentially to the result, but of the two causes I consider that frequent opportunity is the greater.

But the falling of timbermen is not the only mode in which this accident occurs. Another is the product of pure forgetfulness. A man working near the shaft will sometimes step off upon vacancy and meet his death. The movement is made quietly—not in the heat of action, but after the completion of some task—and above ground such actions are attributed to "absent-mindedness." I think this state of inactive perception is exceptionally frequent among Comstock miners, and it stands in such strong contrast to the habits of forethoughtfulness to which they train themselves that we must attribute it to the effect of physical exertion in hot air.

Another class of falls in the shaft are partly due to the high professional spirit and sense of individual responsibility, which makes the Western miner one of the most trustworthy of his class. This mode of occurrence, which is unexpectedly frequent, is the pushing of a car into a shaft where there is no cage. This is sometimes due to pure absent-mindedness, and sometimes to an interruption of the routine work by a cage going up empty, with a message, with tools or with a passenger. It is said to be a fact that when a carman has pushed his car to the open shaft and has suddenly awakened to the dreadful situation, he never fails to sacrifice his own life in efforts, however hopeless, to stop it. Whenever a car thunders down the shaft, there is always a man with it, and whenever the circumstances have come under observation, it has been evident that the loss of life was not due to stupefaction but to a dogged determination to stake everything on the hope of preventing a possible calamity to men below. The spirit is well illustrated by the act of a man who fell down a shaft at Bodie, and used his last breath in calling out "Look out below!" Though this casualty appears so frightful to those who witness it, it is probably as painless as other modes of certain instantaneous death. I have been told that the unfortunate men always lose their shoes in their fall, and

also that they invariably reach the bottom sooner than the car, if one falls with the man.

(5.) The history of blast accidents in the Comstock mines enforces the truth that the nitroglycerine explosives do not enjoy the immunity from ignition by friction which has been asserted for them so confidently. We have to admit that a box of cartridges can be thrown off a house with safety, for that has frequently been done, but inclosed in a drill-hole they have been fired repeatedly by friction, jarring or a blow. Out of fourteen accidents five occurred from the explosion of unsuspected cartridges by one of these causes.

Two cases of wounding are peculiar from the fact that the exploding cartridges had been in the rock a long time. Each of them lay, not in the header, but in the floor of a drift or chamber, and the accident occurred when orders were given to level up the floor. The explosions were in different mines, and one of the miners was using a pick, the other a gad. Neither was killed.

Two men were wounded by the explosion of a cartridge which they were drilling out for repriming. Three accidents occurred from the explosion of old cartridges left in the header, the presence of which was not suspected, and which were fired, not by direct impact of the tool, but by the jar or the crowding in of the rock upon the cartridge owing to the starting of a new drill-hole near by. Two of these were caused by machine drills, and one by hand drilling. It is supposed that in some cases at least the exploding cartridge was not a complete one but merely a fragment, the upper portion having done its work. This seems probable, for instance, in the cases of the two men who were injured while levelling off the floor, for it is hardly conceivable that a full cartridge could blow up the floor beneath a man's feet and leave him alive.

One of the explosions took place under peculiar circumstances, which exhibit very well the sensensitiveness of nitroglycerine to the conditions in which it is placed. A hole having missed fire, the next shift opened and recharged it. After lighting the fuse the men waited the usual time, and one of them then went to the face and found the cartridge was "boiling," making what miners call a "stinker." It was concluded to drown the hole out, and a man took up water from the wet floor in his shovel and threw it on the boiling cartridge. While stooping for another shovelful, the half-burnt charge exploded. The superintend-

ent, Mr. Forman, who was present, attributes the explosion to the confinement of gas by the water, and the suggestion is a sensible one.

(6.) Hoisting on the Comstock has peculiar dangers from the movement of ground in the shafts already spoken of. It is often impossible to keep the guides in anything approaching a straight line. The shove is not only considerable, but it is frequently confined to short reaches in the shaft, and this displacement of line is the cause of frequent dangers and sometimes of serious casualties. The cage sways from side to side, with motion sufficient to make it absolutely necessary to hold firmly to a rod placed in the top for the purpose. Among the casualties of 1877 was one caused by the violent surging of the cage in the Consolidated Virginia shaft, by which a miner was thrown off his balance, one foot going over the side He escaped with a sprained ankle. Sticking of the cage during its descent and its subsequent fall with a jerk, is one of the most frequent causes of these accidents, and the cage sometimes also gives a sudden bound when rising.

(7.) Though overwinding is neither the most frequent source of casualties nor the most fatal in its results, it has aroused more attention than any other. In twenty-two months, cages containing men were twice "run into the sheaves," as the local expression is, and I have notes of four others where no men were hoisted, but one of which proved injurious to persons. Two of the fatal cases occurred at the same mine within five and a half months, and the other, which was caused by overwinding a heavy bailing tank, followed soon after. These, and the running of several empty or ore-laden cages into the sheaves, made a great excitement, and the Society of Engineers tried to prove that the men at the engines were overworked. They formerly worked twelve hours at many shafts, and on solicitation were reduced to eight hours at some. The pay for twelve hours' work was usually $6, and for eight hours $4.50 or $5.

One result of the excitement occasioned by these dreadful casualties was the introduction of several safety devices. Nothing new was presented, there being detaching devices which depended on safety catches for supporting the cage when connection with the cable was severed, others with especial chairs to detain the cage, and one with a rope wound on a false reel to support the cable and carry it quietly to the hoisting drum or reel. In addition the usual appliances for throttling the exhaust from the cylinders of the hoisting engine, shutting off steam gradually and putting on the brake have been re-invented.

The gallows frames at most of the old shafts are thirty-five feet high, and with a "double-decker" cage that takes up twelve or fourteen feet of this space, it is evident the engineer has but a small margin for safety. The new shafts have frames forty-five feet high. It seems to me that the disinclination to use preventive appliances should be overcome. The tendency on the Comstock is to employ unbalanced reels, and with these, mere bleeding of the steam pipe should be sufficient to prevent serious injury. With balanced reels it would be absolutely necessary to put on the brake also.

(8.) One of the accidents classed among the miscellaneous causes is worthy of attention. Several years ago an electric signaling apparatus was introduced into the Savage mine, but abandoned on account of the uncertainty of its signals, which would sometimes sound without human aid. In 1877 a new apparatus was put in with improvements, which it was thought would prevent this disadvantage, but after working well for some time, it failed one morning and caused a fatal casualty by sounding only three bells, when ten were intended. Whether the signal man was at fault is doubtful, but it is a fact that the apparatus had worked badly that morning, and before the accident a man had been stationed to signal with the bell-rope in case the battery did not work. There is little confidence in the electric mode of signaling, and, I believe, it is not in use now in any mine on the lode. A small wire hand-rope is used, and on the whole is safe and convenient.

In looking over this list of casualties it is evident that the accidents which possess most interest are those which have near or remote connection with the heat of the mines, for the latter are sinking with great rapidity, and becoming hotter each year. During the past eighteen months they have been deepened four hundred to six hundred feet, and it is difficult to deny that the greater depth increases the chances of accident in mines which, in addition to the ordinary liabilities of mining work, have the insidious and ever present effects of hot air, water and rock upon the physical and mental condition of the men. While I have never myself doubted the ability of the excellent managers to carry the works in these hot rocks down to the greatest depths that are anticipated for mining in any region, I find there is widespread doubt in the West upon this subject. There is an impression that the Comstock lode has nearly reached the end of the mining rope, and the reason usually given is that life cannot be sustained in the great heat of the lowest workings, which heat the popular mind loves

to exaggerate. The record I present in this paper should be sufficient to dispel such doubts. Out of 101 accidents twelve were directly caused by the heat or hot water. Undoubtedly the falls of men down a shaft have been caused sometimes by sudden exhaustion, due to the heat and steam in upcast shafts, but on looking over the accounts of the accidents of this kind, which are included in the above list, I cannot find any of them that show a connection with this cause. The casualties positively traceable to the heat are, therefore, twelve per cent. of the whole. Probably the heat increases the bad effects of powder fumes and natural gases, and by making repairs to the shafts more frequently necessary it adds indirectly to the occasions when disasters may occur. I also confess to the belief, which is not sustained by observations upon specific casualties, that some allowance should be made for a less active mental condition, a dulling of the faculties, and a certain recklessness to which the heat sometimes goads the men. On the other hand the heat makes them more cautious except when under momentary impulses, and I have never seen American miners more careful of themselves than in these mines. On the whole, the good and bad effects of the heat seem to nearly balance each other, and I think that an allowance of five per cent. for the casualties indirectly caused by the high heat would be sufficient. The specific cases which I present do not warrant even that allowance. The accidents recorded here relate to a time when the number of miners at work in the district was from three thousand to thirty-five hundred, including top men and underground men. Most of them worked eight hours, but some of those on top had twelve hour shifts, and probably there was a constant force of nine hundred or one thousand men below.

It is not possible to make a comparison between these casualties and the amount of ore raised, as the practice is in statistics of coal mines, for the reason that only two out of about forty mines were producing much ore throughout the period covered by the list. The comparison can be made for those two, the Consolidated Virginia and California, and is as follows for the year 1878:

	Proportion to tons ore.
Number of accidents, 10,	1 to 25,771
Fatal casualties, 5,	1 to 51,542
Casualties not fatal, 8,	1 to 32,214

Tons of ore extracted, 257,718.

Of the casualties included in the list for twenty-two months there

were in these two mines twenty-five accidents, twelve fatal, and eighteen not fatal casualties, or twenty-five, twenty-two and a half, and twenty-six per cent. of the whole.

From all these facts I conclude that increasing heat will not debar the Comstock mines from continuing to the greatest depths which are considered practicable in the existing adjustment of mining appliances to the market value of mining products. It is true that an air temperature of 108° Fahr. is common at the 2000 feet level, while 110° and 112° are not infrequently observed, and that a drift which showed a temperature of 123°, 126° and 128° Fahr., according to different reports, has proved to be the most deadly on the lode. It is also true that the temperature of the rock is increasing, and with it that of the air, and at some depth, for the calculation of which there are absolutely no data, the temperature of this drift may be expected to prevail throughout the lode unless the present conditions change. But this being an *air* temperature, it is always possible to mitigate it by artificial means. It is already observable that drifts 1800 feet below the surface may show a much higher heat than others 400 feet below them. High temperature is largely a matter of locality and temporary conditions, and by various expedients it may be confined to its localities, or combated in other ways.

Deep mining, by extending the line of work through the moving hanging wall, and compelling increased repairs to shafts, will perhaps tend to heighten the already great frequency of falls of men.

In addition to the heat, the peculiar mode of timbering in square sets, the almost exclusive use of nitroglycerine powders, the necessity of frequent repairs to shaft timbers, the incessant movement of the rocks through which the shafts are sunk, making accidents in hoisting more than ordinarily frequent, and the necessity of transporting large quantities of rock through narrow gangways entirely by human labor, are the conditions in which mining on the Comstock may be said to suffer rather more than the usual liability to danger. Two of these causes, both connected with the movement of the ground, may be expected to increase with depth. Together with the heat they comprise forty per cent. of the whole number of accidents, and we may therefore sum up our conclusions by saying that the conditions of deep mining will increase forty per cent. of the causes which lead to casualties, and will leave sixty per cent. unaffected. What the amount of this increase will be cannot be foretold, and indeed cannot be estimated until an ore body

has been found and worked at great depth. So far the year 1879, which is pre-eminently one of deep sinking on the Comstock, has been remarkably free from casualties.

The administration of the mines is excellent, and the oversight ample. Though there is no declared law, I observed that an accident was likely to be followed by the discharge of some miners, and several times the sufferers went before a magistrate and made oath that they were not only entirely innocent of negligence, but absolutely ignorant that there was any danger impending, or that there was any one near who could be injured if an accident should take place. The managers seem to have come to the conclusion, which guides the framers of some European mining laws, that accidents will not cease until the damage is assessed on every one in the neighborhood of the casualty, innocent or guilty. The Miners' Union is an active and powerful body, and does not hesitate to express an opinion on the conduct of the mines.

The Compass.—The secret of the steadiness of a large compass is the longness of its vibrational period, and a small card would have the same steadiness as a large one if its vibrational period were the same. How little this is known is illustrated by the methods of procuring steadiness in common use. In some (as in the Admiralty "J" card, provided for use in stormy weather) there is a swelling in the middle of each of the steel needles to make them heavier; in others heavy brass weights are attached to the compass cards as near the centre as may be, being sometimes, for instance, in the form of a small brass ring of about an inch and a half in diameter. Another method, scarcely less scientific, is to blunt the bearing-point by grinding it or striking it with a hammer, as has not unfrequently been done to render the compass "less lively," or to fill the cup with brick-dust, as is reported by the Liverpool Compass Committee to have been once done at sea by a captain who was surprised to find afterwards that his compass could not be trusted within a couple of points. All these methods are founded on the idea that friction on the bearing-point is the cure for unsteadiness. In reality friction introduces a peculiar unsteadiness of a very serious kind, and is very ineffective in remedying the proper unsteadiness of which something is essential and inevitable in a compass on board a ship rolling in a heavy sea and steering on any other course than due east or due west.—*Sir W. Thompson.*

NEW APPLICATION OF RAPID OXIDATION BY WHICH SULPHIDES ARE UTILIZED AS FUEL.

By JOHN HOLLWAY.

This process has for its object the utilization of the heat generated by the rapid oxidation of certain mineral substances which have not hitherto been used as sources of heat for smelting operations. The heat thus obtained is employed in the reduction of the furnace charge, which may be composed partly of sulphides and partly of siliceous ores. A current of air is forced through molten sulphides, by which means they are very rapidly oxidized. Great heat is thus developed, rendering the process of smelting a self-supporting operation; therefore, no extraneous fuel is required, excepting that employed in raising steam for the blowing engines; where, however, water power is available, steam can be dispensed with, in which case all the carbonaceous fuel necessary for the operation is a little coke to start the furnaces, which stands in the same relative position to the ores as wood does to coal in the lighting of an ordinary fire.

It is well known that pyritous minerals are readily combustible, but the best means of utilizing the heat-producing property of metallic sulphides is not so apparent as would at first sight appear. Of these sulphides only iron pyrites is sufficiently combustible at a low temperature to burn in the open air, the mass being raised to the temperature at which the oxidation takes place solely by the union of sulphur and iron with atmospheric oxygen. In Spain there are numerous deposits of poor cupreous pyrites, and the Rio Tinto and Tharsis Companies annually treat, at their mines, about one million tons for the extraction of copper only, which does not average 2 per cent. The process employed consists essentially in roasting the pyrites in heaps in the open air, dissolving out the copper from the roasted material and precipitating it from the solution by means of iron. These operations extend over several months; any gold or silver contained in the ore is lost, and the iron and sulphur are also wasted. The sulphur passes into the air as an obnoxious and annoying gas, desolating the country for miles around the works.

From the earliest ages carbon has been considered a necessity in all

metallurgical operations. The first reduction of metals by means of carbon forms a connecting link between the age of stone and the commencement of civilized art. It is well known that carbon burns at widely varying temperatures, as for example, in our bodies, in a common coal fire, or in a furnace. A great deal of thought has been devoted to the subject of economizing carbonaceous fuel, and great advances have been made in this direction; yet the expenditure of coal or coke necessary, say to melt a given quantity of metal, still far exceeds the theoretical limit. The main causes of this discrepancy may be accounted for as follows:

1. Only part of the oxygen of the air passing into furnace acts on the material to be burnt.

2. The oxygen is not brought in contact with the combustible matter with sufficient rapidity to obtain the necessary temperature for the operation.

3. Gases pass off hot and unburnt. These are now, however, frequently utilized.

There is one metallurgical operation in which the first two sources of loss are avoided, viz., "Bessemer's," where, by blowing air through molten crude iron, a very high temperature is attained by the combustion of small quantities of carbon and silicon contained in the crude iron; this is, however, not the case in the process of puddling, where the oxidation is spread over a considerable period of time, although the same constituents are frequently burnt in similar proportions. But even in the Bessemer process the carbon is only half burned, and a large amount of heat escapes with the carbonic oxide and nitrogen.

When, however, thin streams of air are forced through molten sulphide of iron, lying on a tuyère hearth, a high temperature is produced by the perfect combustion which ensues in the midst of the sulphides, and no unburnt gases, excepting nitrogen and sulphur vapor, escape from the surface of the molten mass. The hot nitrogen and sulphurous acid may be caused to act upon iron pyrites and other mineral matter, and when pyrites are thus heated, an atom of sulphur held in feeble combination is in great part expelled, and thus is obtained molten protosulphide of iron, which is subsequently burnt by the oxygen of the air driven in at the lower part of the furnace, thereby producing the heat necessary for continuing the operation. The process may be defined as a sytem of fractional oxidation, in which the numerous constituents of a complex furnace charge can be separated from

each other and concentrated in different parts of the apparatus, the heat necessary for the operation being obtained by the combustion of a portion of the less valuable constituents.

The principal ores of all our ordinary heavy metals, except manganese and tin, are sulphides. Iron, though largely occurring in an oxidized form, is abundantly found in combination with sulphur; and bisulphide of iron, or iron pyrites, is an example of sulphurous and combustible minerals. Associated with iron and sulphur in iron pyrites are invariably found small quantities of other metals, notably cobalt, nickel, copper, silver, gold, lead, zinc and arsenic. Of these, zinc is almost as combustible as iron itself, while lead and arsenic readily volatilize as sulphides, and cobalt, nickel and copper are distinctly less readily oxidizable than iron, while silver and gold do not oxidize under these conditions; hence, in supplying air to such material, the iron is the first of the elements to suffer oxidation, so that if the oxidation be arrested before the whole of the iron has been burnt, the cobalt, nickel, copper, silver and gold present will be found in the unburnt portion. This principle finds a parallel in the Bessemer process of treating pig-iron for the manufacture of steel, where a current of air is caused to bubble up through a bath of molten crude iron, the silicon is first oxidized, and is closely followed and to a great extent accompanied by the carbon, and no large amount of iron suffers oxidation, until the whole of the silicon and carbon have been burnt out of the molten material.

The experiments made at Messrs. Cammell's works, at Penistone, in a Bessemer converter, have proved that by blowing air through molten sulphide of iron, the iron and a portion of the sulphur are oxidized, and if the oxidation is arrested before the combustion of the iron is complete, a heavy matt or regulus is obtained, which contains but a small proportion of the iron of the ore, but practically the whole or the greater part of the copper and other less oxidizable metals. In one of these experiments the molten sulphides were run into the converter from a cupola in which they had been previously melted, and the temperature was kept up until the operation was discontinued, viz., for a period of ten hours, without the use of any carbonaceous fuel, the heat being entirely derived from the oxidation of the iron and a portion of the sulphur of the lumps of pyrites, which were continuously thrown into the mouth of the converter. A Bessemer converter being unsuited for the collection of the gaseous products, the later

experiments have been made in a series of cupola furnaces belonging to Messrs. John Brown & Company. These experiments have proved the possibility of obtaining a valuable regulus, a slag nearly free from copper, and a considerable quantity of crude sulphur. M. Pourcel, the well-known chemist of the Terrenoire Company, has also made some very interesting experiments, having treated by this method a cupriferous sulphide of antimony containing lead and zinc, using heavy spar and silica as fluxes; he obtained a regulus containing the whole of the copper in the form of sulphide, a slag of light specific grvity, and the lead, zinc and antimony as two separate sublimates which were condensed in different parts of the apparatus, owing to the superior volatility of sulphide of lead over the oxides of antimony and zinc. In the experiments at Penistone and at Sheffield a cold blast of air was employed, and the gases which passed from the converter or furnace into the open air carried away with them a large amount of heat. In practice, however, it would be economical to employ a hot blast, which could be heated by the waste heat from the escaping gases. It is remarkable that the least valuable metals, viz., iron and zinc, generate by their combustion the largest quntities of heat.

The process may be employed for the reduction of even the more volatile metals; for example, Mr. A. H. Allen, of Sheffield, has thus obtained metallic antimony simply by the oxidation of sulphide of antimony. It is well known that sulphide of lead reacts upon oxide of lead with the production of metallic lead and sulphurous acid. If, therefore, a limited amount of air is blown into molten sulphide of lead, the oxide thus formed in the lower part of the furnace will, in passing upward, come in contact with the hot sulphide of lead, and metallic lead will result, with the evolution of sulphurous acid. The furnace having a quiescent hearth below the tuyères, the metallic lead will collect there, and can be from time to time withdrawn. A limited amount of air must be employed, because if it is driven in too quickly, the sulphide of lead will rapidly distil off. In thus treating argentiferous lead ores, the silver (and gold if present) would be found with the first metallic lead reduced. When thus treating galena the furnace should have a basic lining.

The process is peculiarly suitable:

1st. For the treatment of metalliferous substances which cannot be advantageously treated by other processes. For the extr tion of sul-

phur by distillation, and simultaneously for the concentration and separation of cobalt, nickel, copper, silver and gold from minerals in the form of metallic regulus; while lead, zinc, antimony, arsenic, etc., accrue in the sublimates.

2d. For the treatment of complex ores, for example, grey antimonial copper ores, such as those experimented on by M. Pourcel. Ores similar to those worked at the well-known Bottino Mines, Seravezza, in the Italian Appennines, which contain thirteen or fourteen heavy metals, including silver and lead, for which latter alone they have been worked for centuries. The blende of lead mines in Derbyshire termed "muck," usually thrown away by the miners, because the large quantity of lead with which it is associated renders the zinc obtained from it worthless.

3d. For the treatment of auriferous and argentiferous pyrites. It is well known that in practice it is not possible to obtain the whole of the gold from pyrites by amalgamation with quicksilver, because the presence of sulphur and arsenic sickens and flours the mercury, whereas by fusion the whole of the silver and gold present is obtained.

4th. For the treatment of pyrites containing even only small percentages of cobalt, nickel and copper, which are thus concentrated into a rich regulus, whereas this result is now only obtained by very tedious processes of alternate roasting and reduction. Such ores containing 10 per cent. and even 12 per cent. of copper exist in South America and many other parts of the world, but are not at present capable of economic treatment, owing to the difficulty of obtaining a sufficient supply of cheap fuel. The process can also be advantageously applied to the treatment of richer ores of copper such as are at present smelted at Swansea.

5th. For the treatment of poor lead ores. If such ores are added to a furnace charge of cupreous pyrites, the silica they contain will be utilized and combine with the resulting oxide of iron to form slag, the galena will be volatilized and be recovered as a sublimate, while any silver present will enrich the regulus. At present, by a costly process of crushing and washing these ores, the galena is concentrated, although a large proportion is left with the *débris*, and passes with the water into the streams, rendering the existence of fish in such waters impossible. The water power now used for washing the ore could, in many cases, be employed for producing the blast.

When thus treating cupriferous iron pyrites, four products are obtained:

1st. A matt or regulus containing from 30 to 50 per cent. of copper, any traces of cobalt, nickel, silver or gold the ore may contain, the rest of it being iron and sulphur; it has a specific gravity of $4\frac{1}{2}$ to 5.

2d. A slag consisting of silicate of iron from the resulting oxide of iron combined with the siliceous matters contained in the ore and the fluxes added.

3d. Sublimed sulphur, more or less mixed with volatile compounds of lead, zinc and arsenic.

4th. Sulphurous gases consisting mainly of sulphurous acid and nitrogen.

The regulus closely resembles, and will replace, the coarse metal of the Swansea copper process, which is now only obtained at considerable cost of labor, time and carbonaceous fuel. When, however, sulphides of iron and copper present in the bath are treated continuously by a blast of air, a point is at length arrived at when the whole of the iron is oxidized, and the regulus in the bath consists of sub-sulphide of copper. If, now, a limited supply of air is introduced, the copper is reduced to the metallic state with the evolution of sulphurous acid.

The slag obtained in the Penistone experiments was essentially silicate of iron, containing about 50 per cent. of iron and 29 per cent. of silica. It had a density of about 3·8 to 4, and was in composition somewhat allied to the copper-smelter's ore furnace slag and to the tap-cinder of the iron-puddler. By the addition of calcareous materials, the specific gravity of the slag is so reduced as to cause it to separate readily from the regulus which collects below it. In one of the later experiments, when lime was used, the proportion of copper lost in the slag was very small. This is, of course, a most important point, for when dealing with ores containing but little copper, the presence of even a small percentage in the slag means the loss of a considerable proportion of the copper present. These slags can be utilized for the manufacture of steel, being practically siliceous iron ores free from phosphorus, and their reduction in a blast furnace can be profitably effected, as the proportion of iron present is high as compared with the weight of the material; indeed, it may be possible to reduce them while in a molten state.

By re-subliming the crude sulphur, it can be freed from all impurities except arsenic, and at the works of Messrs. John Hutchinson & Co., Widnes, this is eliminated by means of polysulphide of calcium.

As a certain proportion of the sulphur of the minerals suffers com-

bustion, the resulting sulphurous gases contain from 14 to 15 per cent. of sulphurous acid, and hence the proportion of sulphurous acid to nitrogen is nearly identical with that of the gases produced by roasting pyrites in the kilns employed by vitriol manufacturers, and can therefore be used with equal advantage for the production of vitriol in leaden chambers. This appears to be the simplest solution of the great problem how to smelt copper without causing a nuisance to the surrounding neighborhood, although a similar result might be obtained by collecting and liquefying the sulphurous acid.

The more incombustible materials it is found practicable to employ without too great a loss of temperatue, the wider will become the application of the process; for there are many ores, including silicates and carbonates, containing metals in the form of oxides, which might be conveniently smelted by mixing them with a sufficient proportion of pyritous ores to effect their reduction; in fact, one of the chief practical questions connected with this process is how far it may be trusted to effect the smelting of ores or furnace charges containing comparatively moderate proportions of sulphides. It is evident that it will almost entirely obviate the necessity for using carbonaceous fuel, at least as far as the production of a regulus is concerned, and consequently the localities in which smelting operations may be advantageously carried on are thus greatly multiplied. One of its chief merits is that it is equally applicable with comparatively little extra cost in the working, to very poor and very rich ores, for however small the resulting regulus, it will contain nearly the whole of the cobalt, nickel, copper, silver and gold present in the furnace charge, while any lead, zinc, antimony and arsenic will be obtained as sublimates.—*Nature.*

Confirmation of Prediction.—M. A. Gorgen has succeeded in making an artificial deutoxide of manganese, having all the properties and characteristics of polianite. It was obtained by heating nitrate of manganese, very slowly and for a considerable time, at a temperature of from 155° to 162° (311° to 323·6° Fahr.), in a glass phial placed in a bath of oil or paraffine. His experiments confirm the hypothesis which was published in 1860 by MM. Sainte-Claire Deville and Debray.—*Comptes Rendus.* C.

THE LIGHT AND ENERGY OF ELECTRICITY AND GAS.

By J. T. Sprague.

Some very remarkable statements were made before the Committee of Parliament on Lighting by Electricity. These statements are embodied in the report, and having gone the rounds of the press without examination or comment, they will, no doubt, be adopted as settled facts. It is, therefore, very desirable that they should be examined, and that an understanding should be arrived at as to how far they are reliable, and in what sense they are true. We will, therefore, commence with the remarks of Sir William Thomson.

1746. We are anxious to obtain your opinion upon various points connected with electric lighting; perhaps you will let me go to the root of the matter, and ask you to tell us the energy which is used and exhibited as light in the production of the electric arc?—The energy which is actually used in the electric arc is about 1 horse-power per 2400 candle-power, or even more than 2400 candle-power, according to the dimensions and other circumstances of the electric arc.

1747. That is to say, 1 horse-power, if fully employed, produces 2400 candles or more?—Yes, 1 horse-power actually in the electric arc; 1 horse-power spent in stirring the luminiferous ether between the carbon points and on the surfaces of the carbon.

1748. Have you at all calculated the energy appearing as light in the case of the combustion of gas?—1 horse-power of energy in the combustion of gas produces about 12 candle-power.

1749. And one horse-power converted into electric light produces 2400 candles?—Yes.

1750. As these are rather startling figures, perhaps you will explain to the committee how you arrive at such results?—Sir William's reply is too lengthy for full quotation, as the greater part of it is unimportant; he concludes by saying: "The upshot of all is that, allowing the practical estimate of 1 horse-power actually spent in driving the engine to produce 1200 candles, which has been realized, I estimate that one-half of that power goes to the electric arc, and one-half is lost in heating different parts of the machine. *This then gives* 2400 *candles for* 1 *horse-power,* which is the figure of my answer. In respete to gas I

have taken 4 candles per cubic foot of gas per hour. I have taken the heating power of gas at 12,000 centigrade units per gramme; I have taken the specific gravity of the gas as half that of air, and calculated accordingly. I have thus calculated the *whole heat of the combustion of gas*, from the amount of that per second of time, and reduced it to horse-power. Thus I arrive at the figure which I gave in my answer, *i. e.*, 1 horse-power actually spent in warming the air and stirring the luminiferous ether in a gas flame of 12 candle-power."

The committee in their report remark that there is some difference of opinion between the scientific and practical witnesses, and it is not to be wondered at if the foregoing is to be taken as a type of scientific evidence. In fact, the statements are all true, but they are so arranged as to constitute a complete chain of special pleading, and to convey an absolutely false impression of what the facts themselves really mean. The statements are *true as to the energy actually in the lights.* The impression they produce *is false as to the energy necessary to produce the lights.*

There are two ways of considering energy, as with most other things. There is the *potential* or theoretical energy of a combustible; that is to say, the total heat capable of being produced by its union with oxygen. This potential energy of coal, for instance, is about 13,000 centigrade heat units per pound. In commercial language, we may call this the *gross* energy of the coal. There is, again, the *practical* energy of the combustible, a function of the boilers and engines. For instance, average steam engines give a horse-power for seven pound of coal per hour; this, in commercial language, may be called the net energy of the coal.

Now, what Sir William Thomson has done is just this: he has charged the gas light with the gross energy, and the electric light with the net energy, as indicated by the italics in his evidence, and people who do not understand this, like the writers in the daily press, of course imagine that these figures so seriously stated are really true.

Now let us see what would come of an equitable comparison, using, as far as possible, Sir William Thomson's own figures.

1 horse-power is 33,000 ft.-lb. per minute, or 1,980,000 per hour. Expressed in heat units of 1 lb. water 1° Cent., which equals 1390 ft.-lb., 1 horse-power per hour equals 1424·5. This, then, is the potential energy of the 4 cubic feet of gas, giving 12 candles light.

To put the 1 horse-power of energy into the electric arc another 1

horse-power is of necessity expended in the circuit and must be charged, because the gas compared with it is the whole amount necessary. But to produce 1 horse-power in a steam engine involves a consumption of coal varying from 2·5 pounds, in the most perfect and expensive engines known, to 8 and even 10 pounds in common engines; let us take 4 pounds as a very fair engine's work and we have 8 pounds coal expended in generating the 2400 candles mentioned. Now, the potential energy of 1 pound of average coal is 13,000 heat units, or, in 8 pounds, 104,000.

Instead of having the energy per candle:

Gas, . . . 1424·5 ÷ 12 = 118·7

Electricity, . . 1424·5 ÷ 2400 = 0·597

This being what Sir William Thomson makes it appear to be, we have, by equitable comparison:

Gas, . . . 1424·5 ÷ 12 = 118·7

Electricity, . . 104,000 ÷ 2400 = 43·3

Even then we have omitted a very important element of consideration: the gas light needs no machinery, no capital outlay, no skilled attendance; the electric light wants all these, and if they do not form an element of the scientific calculation as to potential energy involved in the two cases, they enter very largely as factors in the practical calculation as to the potential cost. Hence the difference in the practical and so-called scientific opinions noted in the committee's report.

The comparisons made are, however, intrinsically erroneous, because made between electricity in its best conditions on the large scale, and gas in its worst on the small scale, and it is well known that in all things the small scale is most costly, whether we consider the expenditure of money or of energy. But, in addition to this general principle the comparison is not really made with an electric arc having 1 horse-power of energy expended in it. The estimate is made from a light having 3 or 4 horse-power in it; in this way the value is arrived at "of 1 horse-power actually employed in driving the engine to produce 1200 candles," and as only half this energy is in the arc, the light equal to 1 horse-power is taken as 2400; but it is well known that to produce a light of 1200 candles in a single arc requires 2 horse power of engine, and in those conditions the 1 horse-power energy would be actually in the arc, and the efficiency would be:

Electricity, . . 104,000 ÷ 1200 = 86·6.

as against gas 118·7 per candle, and this when setting the production of a 12-candle light against one of 1200.

It may be well to explain why the actual energy expended in the luminous area is so much smaller with electricity than with any combustible such as gas. In the case of combustion the energy has to be employed in heating the products of the combustion, steam and carbonic acid and a large bulk of neutral nitrogen from the air; these all flow rapidly away and carry off the heat. The very same loss has to be met in the electricity when derived from combustion, but the loss occurs, not in the light, but in the furnace and in the wires; here pure energy is collected and transmitted to the arc, where it makes its appearance as light unencumbered by the products of the processes of the transformation of latent energy into light and heat. Still, as the loss has to be incurred in both cases, both the lights when compared must have the total energy needed for their development taken into account.

The same witness expressed opinions as to the transmission of power from central engines to different parts of towns by means of electricity, but as Mr. Siemens gave the figures upon which these opinions are founded, we may now pass on to examine these. Mr. Siemens, comparing the cost of gas and electricity, says: "(136.) Making the unit of comparison 1000 standard candles per hour, the results are striking. An Argand burner produced 1000 standard candles of light per hour, with a consumption of 312·5 cubic feet of gas; and to make this, 56 pounds of coal would have to be used in the retorts. (139.) In the case of a medium dynamo-machine driven by a gas engine, 19·5 cubic feet of gas produce 1000 standard candles during one hour; and the consumption of coal necessary to produce this gas is 3·26 pounds. (141.) And in the case of the naked light the consumption of coal is very nearly the same?—It is very nearly the same: it is 13·3 pounds in the gas engine, and 12 pounds in the steam engine, showing that the gas engine is really a very economical engine, and has moreover the advantage over the steam engine, that no boiler is employed, and that the consumption of gas commences and ceases the moment the motion of the engine commences and ceases."

It will be seen presently that this advantage of the gas engine is very much understated, because the coal corresponding to the gas is largely overestimated.

The comparison between the relative weights of coal consumed is really of little importance, because the real thing to be considered is

the relative costs. The cost of gas is, of course, greater than that of the mere coal it represents, because its price includes labor, capital and distribution; on the other hand, the coal consumed in the other case must be charged with wages, etc., necessary for its consumption to place it on the same footing as the gas with which it is compared. But when any comparison is made or any line of argument adopted it ought to be correctly worked out.

Now, instead of an Argand burner giving the light of 1000 candles on a consumption of 312·5 feet of gas per hour, this value is calculated from the work of 62 Argand burners, each consuming only 5 feet per hour of 16-candle gas. No burner of 1000 candle-power has been made. But burners giving 250 candles on a consumption of 60 feet are made, so that we know that 1000 candles can be obtained from 240 feet instead of 312·5. But Mr. Siemens commits a more serious injustice when he charges against the gas the whole of the coal put into the retort, allowing nothing for the coke and tar, which form part of the actual coal with which he is comparing the gas. In this way he obtains a consumption of 15 pounds of coal per hour with gas as against 8 pounds consumed in a steam engine to develop the 2 horse-power necessary to develop 1000 candles in one electric arc.

A ton of average coal gives 9600 feet of gas of 0·450 sp. gr. which equals 331 pounds of purified gas per ton; about 1300 pounds of coke are produced, and if we reckon the excessive consumption of one-third of this in the furnaces and charge the whole of this against the gas produced we shall find that we get about 12 feet of gas for each pound of coal which has disappeared—that is to say, 100 cubic feet of gas represented, at most, 8 pounds of coals. This reduces Mr. Siemens' 56 pounds per 1000 candles to 25 pounds on the consumption of 5 feet Argands, and to 19 pounds on the actual consumption in 4 of the 250 candle burners.

This shows the great economy of the gas engine as compared with the steam engine. Gas engines are already in use which develop 1 horse-power per 21 feet of gas, which represents at most 1·6 pounds of coal, and this efficiency is realized in small engines. But the very best steam engines of large dimensions have never realized more than 1 horse-power for 2·5 pounds of coal, and this only with great attention. Ordinary engines consume 8 and 10 pounds per hour per horse-power, and a consumption of 4 pounds would be very good work for any engine employed under general conditions analogous to those for which

gas engines would be used. The reason of this economy is that the potential energy of the fuel is converted directly into mechanical energy in the cylinder by the act of combustion; only so much is necessarily carried off as goes with the heated products containing only the small quantity of vapor due to the hydrogen in the gas. With steam all this loss occurs in the furnace of the boiler, and in addition there is the immense quantity carried off in the escaping uncondensed steam.

We now come naturally to the question of transmitting power. Mr. Siemens says: (200) "I believe it would be the cheapest mode of transmitting power to a considerable distance. The experiments which we have made give a result of a loss of 50 per cent., that is to say, 5 horse-power applied to a dynamo-machine produces, roughly speaking, 2½ horse-power at a distant point; it would follow that, say, 100 horse-power engine at a central station, which could be worked with a consumption of 2·5 pounds per horse-power, would produce at a number of points, power at the rate of 5 pounds per horse-power."

Mr. Siemens thinks more favorable results may be hoped for than 50 per cent. return; but it is a pretty general law in electricity that the resistances must be equal in generator and utilizer, and there are reasons for this, which the resistance expresses, though it is itself an agent and not the cause; hence 50 per cent. is the full theoretical efficiency, allowing nothing for loss in the conductor and by leakage; in actual working the total efficiency would be more likely 30 to 40 per cent.

But giving electricity its utmost claim, and the use of the best engines known, we have a consumption of coal of 5 pounds per horse-power delivered, as against 1·6 pounds per horse-power delivered by gas. But we have to consider something besides the theoretical consumption of coal. The 21 feet of gas at 4s. per 1000 costs 1d., while 1d. would buy 9·3 pounds of coal at 20s. per ton. But the 1d. in the case of gas covers the whole cost of the delivery of the energy of the coal to the machine which uses it. In the case of coal it represents, on the other hand, energy which has to be delivered; to place the electric energy of that coal on a par with the gas we have to provide and pay for:

1. The capital outlay, wear and tear of the steam engine, and its attendance.

2. The dynamo machine which generates the electric current, and all its subsidiary expenses.

3. A conducting system, the conditions and difficulties of which are as yet absolutely untested.

4. The general expenses of management and the profits of the undertaking.

These simply represent the gas works and mains, and the expenses and profits of the gas company, all of which are included in the penny charged for the horse-power of gas. The consumer would have in either case to provide a gas engine or dynamo-electric apparatus, the costs of which would be about the same.

It is quite certain that the expenses of all this would raise the cost of the 5 pounds of coal consumed at the central station to considerably more than the penny; in fact, they would be so great that it is not surprising that no one has yet ventured to dispute the remarks made some time ago on Mr. Siemens' proposal to transmit the energy of waterfalls 30 miles distant, or of the coal at the pit's mouth. The power costing nothing at the 30 miles distance, it would be better economy to allow to run to waste, its delivery would cost more than the expenses of carriage of coal, which has to be paid for, and its conversion into gas in the different towns as required.

As the writer himself is working at the problem of electric lighting, and is the patentee of machines which will be brought into operation in a little while, it will be understood that there can be no intention to depreciate the importance of these applications of electricity. But the statements examined will no doubt be utilized ere long by the various prospectus writers, who are waiting their opportunity; and it is of great importance that their actual meaning should be understood and the real truth be presented to the public understanding.—*English Mechanic.*

New Application of Paper.—In the Portsmouth dry-dock a vessel was hauled up for repairs, and it was observed that a portion of the hull, to which a piece of paper adhered, was free from grass and mussels. Experiments were instituted which led to an application for a patent for paper sheathing. As it can easily be impregnated with poison, it will probably act as a protection against borers as well as against ordinary fouling.—*Fortschr. der Zeit.* C.

THE IRON AND STEEL PRODUCTION OF AMERICA.

One of the most important industries of the country, and one which promises to attain under the brighter skies of the present year even greater proportions than it now has, is the iron trade. While in England the iron trade was greatly prostrated last year, and continues to be in a state of extraordinary depression, bringing hardship and suffering to many thousands of operatives, its condition in the United States in 1878 showed an encouraging improvement over 1877, and the prospects of 1879 are hopeful.

Mr. James N. Swank, the secretary of the American Iron and Steel Association, reports that our founders have no present fear of foreign competition. The iron manufacturers of England, indeed, have reluctantly given up the United States market as hopelessly lost, and this loss has greatly helped to depress the industry in that country and to increase the gloom which rests over its future. Whereas our imports of railroad iron amounted to nearly 20,000,000 dollars in 1872, in 1878 they fell off to the insignificant sum of 530 dollars.

The statistics of the iron trade of the United States show that our production of pig iron in 1878 was 2,577,361 tons, against 2,314,585 tons in 1877, though there were 16 fewer furnaces in blast at the close of last year than at the close of 1877. This, of course, shows that those actually at work produced more on an average than in the latter year; but the prices of pig iron are so low that many furnaces were run without a profit. While in both steel and iron rails there was an improvement, in pig and bar iron there was a decline from the exceptionally low prices of 1877, in one case a decline of 1 dollar 50 cents a ton, and in the other of 2 dollars 24 cents a ton. The founders hope, however, that prices have at last reached the lowest point to which they can fall, and anticipate a continuance of the increased demand which characterized the old year.

The manufacture of Bessemer steel made healthy progress during 1878, and the prospects for 1879 are very bright. The rapid development of this industry in the Unired States has put us in such a position that we are now independent of the rest of the world in the steel matter, and foreign competition has no terrors for our makers. Like the rest of the iron men they are satisfied with the present tariff,

and ask no greater odds than they now have. Some of them even think they would not suffer were the duties lowered, and they share the conviction so generally entertained in England that the United States will never again be a valuable customer for the British manufacturers of Bessemer steel. The perfection of our steel furnaces has lately won favorable mention in Germany, where the steel manufacturers are clamoring for a protective duty, which, it seems likely, they will not fail to get, for they have Prince Bismarck on their side. Dr. Wadding, a well-known German statistician, has ascertained that Prussia is so far behind the United States in steel making that while the latter, with twenty-two converters, produced in 1875 over 375,517 tons of steel, the former, with thirty-five converters in operation, only produced 284,591 tons, showing a production nearly double in our favor; and he ascribed our greater turn-out entirely to the superior mechanical appliances possessed by our works. In 1877 we manufactured of steel ingots 560,587 net tons, and of Bessemer rails 432,169 tons. In 1878 the product was 732,000 net tons of ingots and 600,000 tons of rails. This is a very handsome gain, and it justifies the cheerfulness which prevails among the manufacturers of steel. Putting the iron and steel rail production of the year together, the total amounts to 930,000 tons, a total only once exceeded in our history, and that in 1872, when the product reached a million. Even that immense manufacture will probably be equaled, if not exceeded in 1879.

The year 1878, on the whole so encouraging to our future iron industry, was one of great disaster to that of Germany, and the present movement for protection in that empire largely springs from its misfortunes, which have been accumulating since 1875. Since 1876 things have been going from bad to worse, and now, in the words of a writer in the London *Times*, the iron trade in Germany is in a state "worse, unquestionably, than that of any other country." The famous Krupp works at Essen, the largest in the world, employing two years ago 10,500 workmen in factory and 5000 more in the mines and blast furnaces, have suffered heavily, while between April, 1873, and April, 1877, the number of workmen employed by twenty-two of the principal companies, exclusive of Krupp's, fell off from 27,700 to 14,600. The German founders are dissatisfied with this state of things, and with Prince Bismarck as their powerful ally they are working for a protective tariff, which, the prospects are, they will assuredly get.

Meantime the British Iron Trade Association is doing its best, through Lord Salisbury, to defeat their efforts, but with little hope of success. How much Great Britain would lose by the imposition of protective duties on iron by Germany is shown by the statistics of her exports of iron to that country. During 1877 Scotland sent her 127,355 tons of pig iron, and England 200,000 tons, while of English steel rails Germany took 21,365 tons.

The following are extracts from the report of the American Iron and Steel Association:

"In nearly all branches of the domestic iron and steel industry enumerated there has been an increased production in 1878 over 1877; but this increased production has been accompanied by a decrease in prices. At no time in the history of the country have prices for iron and steel been so low as they were in 1878, excepting perhaps in Colonial days, when the price of pig iron was lower. The year 1878 witnessed an increased production of pig iron in the United States over the year 1877, as 1877 had witnessed an increased production over 1876, which was the year of lowest production since the panic of 1873. The production of pig iron in 1878 was 2,577,361 tons of 2000 lbs., showing a gain over 1876 of nearly half a million tons. If a similar rate of increase be maintained in 1879, as we have no doubt it will be, the production of this year will equal that of either of the exceptionally productive years, 1872 and 1873, while a much less rate of increase will carry our production in 1880 above 3,000,000 tons.

"It is demonstrated that the consumption of pig iron in the country has greatly increased since 1876; and this increased consumption is not wholly accounted for by the growth in the past two years of the Bessemer branch of our steel industry, rapidly as it had been developed. The production of iron rails and all forms of rolled iron was but little greater in 1878 than in 1876, and fair to infer that the increased consumption of pig iron was partly due to increased activity in our steel works, and partly to improvement in the general business of the country, as shown in increased business done in our foundries and machine shops. Prices of pig iron declined steadily in 1877 and 1878, as they had previously since 1872. The average yearly price of No. 1 anthracite foundry pig iron at Philadelphia in 1872 was 48 dollars 87 cents. In 1878, 17 dollars 62 cents. Of the total production in 1878, of 2,577,361 net tons of pig iron, 1,092,870 tons were made

with anthracite coal; 1,191,092 tons were made with bituminous coal and coke; and 293,399 tons were made with charcoal.

"For two yeas past there has been a steady increase in production of pig iron from bituminous coal and coke, while of charcoal iron the production has declind from 575,000 tons in 1874, to 293,399 tons last year. Less than fifty years ago all the pig iron produced in the country was made with charcoal; in 1878, less than 12 per cent. The use of coke as a blast furnace fuel has steadily increased, and been invading districts heretofore extensively appropriated by anthracite coal.

"Fifteen States increased their production of pig iron in 1878, while Maine, Massachusetts, Maryland, Michigan and Missouri decreased production. North Carolina, Texas and Indiana made pig iron 1877, but none in 1878. None of the Territories made pig iron in 1877 or 1878. Of the total product of 2,577,361 tons in 1878, Pennsylvania made 1,342,633 tons, or just 52 per cent. No new iron-making territory has been developed during the past few years, except the Hocking Valley, in Ohio, which produced 65,690 tons of pig iron in 1878, against 23,895 tons in 1877.

"At the date of preparation of this report in April, 1879, nine new furnaces were in course of erection, but more furnaces are being abandoned than are being built, which shows the number of blast furnaces in the country to be decreasing.

"The Secretary has a list of 692 furnaces in the country at the close of 1878, some of which he adds will never again make pig iron. Of this large number only 265 were in blast at the close of 1878. At the close of 1877 the number in blast was 270. As the production of pig iron was 262,776 tons greater in 1878 than in 1877, it is clear from a comparison of the number of furnaces in blast in each of those years that our furnace practice greatly improved in 1878.

"The improvement in blast furnace practice since the panic struck the country in 1873 is indeed most striking, as shown by statistics of production of the blast furnaces of the country in that year as compared with that of 1878. In the former year the average product of each furnace in blast was 6996, while that of 1878 was 9726 tons, showing a gain of nearly 40 per cent. in five years.

"Part of this is due to larger furnaces, and part to greater skill in all details of furnace management, and a part to increased use of better ores and of Connellsville coke. The production of Spiegeleisen,

which is so necessary in the manufacture of Bessemer steel, was carried on last year in but two States, viz., Pennsylvania and New Jersey, and but 10,674 tons was produced.

"The production of iron and steel rails in the United States in 1878 was 882,685 net tons. This product has been but twice exceeded in the history of the country, in 1872 and 1873. In the former year it reached 1,000,000 tons. The increased production in 1878 over 1877 was 117,976 tons. The product of 1878 was composed of 550,398 tons of Bessemer steel rails; 322,890 tons of iron rails, and 9397 tons of open-hearth steel rails. The production of Bessemer steel rails was 118,229 tons greater in 1878 than in 1877, while that of iron rails was 9650 tons less. Open-hearth steel rails appear in the statistics of last year's rail production for the first time. In 1879 we shall probably produce as many rails as in 1872, when we made 1,000,000 tons. The production of street rails in 1878 is included in the aggregate production for the year, and amounted to 9229 tons. Nineteen States and the Territory of Wyoming made rails in 1878. In 1877, Michigan dropped out of the list of rail-making States, and in 1878 Colorado entered the list. Utah has a mill for re-rolling iron rails.

"In spite of the hard times, it will be seen that the iron industry is steadily making gains in the West.

"Bar-iron sold at Philadelphia, during 1878, and the country at large, at $1\frac{9}{10}$ to 2 cents per pound, while in Pittsburg the average for the year was $1\frac{3}{4}$ cents, or 39.20 per ton. The price of nails at Pittsburg fell steadily during 1878, and in December touched the extraordinary low figure of $1.85 per keg. At date of report the nail trade at Pittsburg and other points West was much demoralized on account of over-production, the price being about $1.90.

"The development of the steel industry in the United States is one of the marvels of our time. At the outbreak of the war of the rebellion the manufacture was indeed in its infancy, but it was advanced with gigantic strides until, in the years of 1875 and 1877, the production of crucible and all other kinds of steel, except Bessemer and open-hearth steel, exceeded 52,000 tons in each year. Last year the production fell off a little, showing 51,462 net tons; but including Bessemer and every kind of steel produced, we have the grand total of 819,814 tons, which, coupled with the low prices at which it has been sold, should convince every American of the wisdom of the protection

policy, and of the extreme folly of further refusing to recognize its benefits.

"Of the eleven Bessemer steel works in the country only one, the Vulcan, of St. Louis, was idle last year. Down to the close of 1878 this country had produced a total of 2,145,595 net tons of Bessemer steel rails. Blooms and billets from ore are made mainly in the Champlain district of New York; blooms from pig and scrap iron are made mainly in Pennsylvania. Of this class of iron the production is not as great now as five years ago.

"The decline in pig-iron was 59 per cent.; in bar-iron 49 per cent.; in steel rails 65 per cent., and in iron rails 56 per cent.

"For the first time steel rails appear among the exports for 1878, the quantity exported being 249 net tons. There was a decline in our export of stoves from $141,361 in 1877, to $98,837 in 1878. The exports of locomotives increased from 64 in 1877, to 82 in 1878, and a large increase in the exports of stationary engines and boilers.

"The cessation of war in Europe caused a heavy decline in our export of fire-arms as compared with 1877. The aggregate value of our exports of iron and steel, and manufactures of the same to all countries in 1878 was $13,260,369. This, however, does not include the following items of manufacture, and which are largely composed of iron and steel, agricultural implements, scales and balances, sewing machines, fire engines and apparatus. The export of these articles amounted to $4,732,126 in 1878, showing a gain of $843,930 over 1877."

Production of iron in tons in the United States in the past two years:

	1877.	1878.
Pig iron,	2,314,585	2,577,361
Stocks of pig iron unsold, December 31,	642,351	574,565
Bars, angles, bolts, rods and hoops,	720,531	830,837
Plates and sheets,	182,242	182,042
Nails in kegs,	4,828,918	4,396,130
Iron rails,	332,540	322,890
Bessemer steel rails,	432,169	550,398
Open-hearth steel rails,	——	9,397
Total production of rails,	764,709	882,685
Bessemer steel ingots,	560,587	732,226
Crucible cast steel,	40,430	42,906
Open-hearth steel ingots,	25,031	36,126
All other steel,	11,924	8,556
Spiegeleisen (included in pig iron above),	8,845	10,674
Blooms from ore and pig metal,	47,300	50,045

Additional Statistics.	1877. Dollars.	1878. Dollars.
Value of iron and steel imports,	9,195,368	8,943,043
" " exports,	16,659,675	13,260,369
Miles of railway constructed,	2,177	2,747
Number of immigrants,	130,503	153,207
Production of Lake Superior iron ore in gross tons,	1,025,129	1,125,231
Tonnage of iron ships built (in fiscal years),	5,927	26,960
Net imports on merchandise (in fiscal years),	438,518,130	422,895,034
Domestic exports of merchandise (in fiscal years),	589,670,224	680,709,258
Net imports of specie (in fiscal years),	27,746,915	23,134,074
Domestic exports of specie (in fiscal years),	43,134,738	27,061,885

—*New York Sun.*

Anomalies of Terrestrial Magnetism.—An interesting discussion has arisen in the French Academy between MM. C. Flammarion and Marié-Davy, in regard to an unexplained anomaly in the magnetic observations at Paris. In order to correspond with the eleven-year variation, the amplitude of the daily oscillation should have descended, between 1871 and 1878, from 12′ to 5′. Instead of this progressive diminution it fluctuated abnormally between 9′ and 10′. In order to get more accordant results Marié-Davy proposed to take the difference between the positions of the needle at 3 P.M. and at midnight, but Flammarion objected, because the greatest eastern elongation is generally about 8 A.M., and the greatest western deviation is about 1 P.M. The amplitude of an oscillation should cover the entire range, and should not be arbitrarily limited to two-thirds or three-quarters of the range. Other forcible objections were urged, and among the possible sources of the anomaly attention is directed to the situation of the observatory, at the crossing of two railway lines, and to the methods and hours of observation. In view of the great importance that is now generally attached to magnetic observations, it is important to remove, so far as possible, all anomalies.—*Comptes Rendus.* C.

THE "POLYPHEMUS."

The torpedo ram *Polyphemus*, now being constructed in Chatham Dockyard, appears likely to be the most extraordinary ship that has yet been built. She is novel and peculiar alike in form, structure, fittings and arrangement of armor protection, while her weapons of attack are such as will necessitate her being fought differently from any other war ship. Her design was described by the late Mr. Ward Hunt in the House of Commons on the 12th of March, 1877, as being "of a kind as yet unknown in any part of the world, but which has been much talked about, and has been at last forced upon me by that gallant officer who stands at the head of the veteran list of the navy, viz.: Sir George Sartorius, who has shown that although his age is great, his mind is still youthful, and that he is willing to receive new ideas and able to inculcate them."

The leading features of the *Polyphemus* are a strong ram bow, a powerful torpedo battery, great speed and handiness, moderate size, and a small extent of surface above water exposed to the enemy's fire, such portion of the vessel as is above the water line being convex in form, so as to deflect any projectile that may strike it. The appearance she will present, when at sea, will be that of a cylinder, floating on its side and deeply immersed, which is tapered at the ends to form a bow and stern. The top of the cylinder will be 4 feet 6 inches above the water line, and will be flattened over a large portion of its area to form a deck. The whole of this flattened cylindrical surface will be plated over with steel armor, and will cover in and protect the ship and all her machinery and fighting appliances. The ship proper, as she will thus appear, will be surmounted by a light structure carrying a hurricane deck of about two-thirds her length, and upon this deck will be seen a signal mast, funnel, pilot tower, boat and other fittings.

Under water the form of the *Polyphemus* is as strange as it will thus appear above. The cylindrical curvature of the sides is carried down several feet below the water line, and armor-plated to that depth. Below this point the section assumes a V form, and ends in a sharp angle at the keel. It will therefore be seen that a complete cross-section of the vessel is very similar to that of a peg top. The flattened convex curvature of the upper part of the peg top would represent the

part of the *Polyphemus* that is above water, and the lower portion, which ends in a point, would also represent the part of the ship that is below water. If the peg top be imagined to float in water at a depth below where its breadth is greatest and where the section thus begins to curve towards the centre line, a rough idea may be obtained both of the form and proportions of the above and under-water parts of the *Polyphemus*.

The *Polyphemus* is 240 feet long between perpendiculars, 40 feet in extreme breadth, and will have a load draught of 20 feet. Her displacement will be 2640 tons. The convex armored deck will be 4 feet 6 inches above the water line, and will be completely plated over with steel armor 3 inches thick. This armor will be carried to a depth of six to seven feet below the water line. The *Polyphemus* will not be fitted with masts or sails, but will carry a pole for signaling purposes and for making observations from. She will be propelled by twin screws, and will have two pairs of high-pressure compound horizontal engines, which are being constructed by Messrs. Humphreys & Tennant, of Deptford. Each high-pressure cylinder will be 38 inches in diameter, and the low-pressure 64 inches. The stroke will be 45 inches. The boilers will be of the locomotive type, twelve in number, and will be made of steel. They will work up to a pressure of 110 pounds per square inch. It is estimated that the engines will indicate a collective power of 5500 horses, and that the speed of the ship will be 17 knots.

The only offensive weapons the *Polyphemus* will possess are a powerful ram bow and Whitehead torpedoes. She will have no guns at all, except a few light shell guns and Gatlings on the hurricane deck for the purpose of repelling boat or torpedo attack. The ram will consist of a very strong spur, which will project 12 feet in advance of the stem of the ship, and is so placed that it will strike several feet below an enemy's armor. It will be connected to the stem and bow by deep web plates and angles on each side; the former being a continuation of the 3-inch deck armor, which is curved downwards at the bow and carried under water till it reaches the level of the spur. The spur is being fitted so that it may be unshipped and taken off the stem when not required for active use. Under the ram is a torpedo port, which will enable Whitehead torpedoes to be ejected right ahead of the ship. There are also two torpedo ports on each side amidships, from which they will be ejected on the broadsides. The ports and apparatus for

working the torpedoes will be upon the system fitted in the *Vesuvius* and *Glatton*. All the torpedo ports are below water, but it is understood that this under-water attack will be supplemented by torpedo firing above water from the armored deck upon the system adopted in ordinary torpedo launches.

Above the armor-plated portion of the hull a hurricane deck is fitted for about two-thirds of its length. This deck is about one-half the extreme breadth of the ship. Communication is made between the hurricane deck and the interior of the ship by openings cut through the armored deck. The openings thus cut are protected by glacis plates and armor, and by casings, which are carried up to the hurricane deck. The boats are carried upon the hurricane deck, and the ship is steered and worked from it. An armored pilot tower, with protected means of access to the lower part of the ship, is placed at the fore end of the hurricane deck, and fitted with steering wheel, telegraphs, voice pipes, apparatus for firing off the torpedoes, and all other appliances for conning and working the ship. A few light shell or Gatling guns will also be carried on the hurricane deck, as we have stated, for repelling boarders or torpedo boats.

The *Polyphemus* is built throughout of steel. The frames are of Bessemer, and the bottom plating of Landore-Siemens steel. She is constructed upon the usual system of transverse bracket frames and continuous longitudinals, and has a double bottom the whole length of the ship right up to the upper deck.

The subdivision of the lower part of the ship into small watertight compartments has been carried as far as appears possible. The double bottom is split up into a large number of cellular spaces, and the hold is divided by a longitudinal middle line bulkhead, and numerous transverse bulkheads. The boilers are contained in four separate watertight compartments of the hold, three being placed in each, and each pair of engines is also contained in a separate watertight compartment. The advantage of such an arrangement is sufficiently obvious, in view of the possibility of one of the boilers or engine rooms being bilged by a blow from a ram or torpedo. The double bottom is arranged so as to include the coal bunkers, as in the *Devastation* and *Inflexible*. By these means buoyancy is gained if one of the compartments is opened up to the sea, as the water can only find its way among the interstices of the coal, and a large quantity is thus kept out of the ship.

The cabins and accommodations for the crew will all be below the

armored deck, and will be ventilated artificially, as in the ironclad monitors. They will be lighted throughout by the electric light, which is already being fitted in several ironclads, and is likely to become extensively used for this purpose. An electric light will also be fixed in the lookout on the polemast, for reconnoitering and signaling purposes.

The most remarkable and novel feature in the ship yet remains to be described. The bottom plating on each side, instead of ending in a keel or flat keel plate at the middle line, is formed into a recess; so that in place of a keel there is a rectangular groove, 1 foot 8 inches wide and 3 feet deep, taken out of the bottom of the ship. This groove or recess is intended to be filled with cast iron ballast up to a weight of 300 tons. The ballast will be cast in several lengths, and will be so attached to the ship that, in the event of a compartment becoming bilged and its being desirable to lighten the ship, the ballast can be let go and dropped from any part, as may be required. The draught and trim may thus be regulated to a certain limited extent should the vessel be damaged in action. This is a point that will probably be discussed among engineers. The object of carrying the ballast seems to be to keep the ship down in the water, and prevent the deck from becoming too much exposed when the ship is uninjured; but should she become still further immersed from any cause, the dropping of the ballast will somewhat relieve and lighten her. The utmost effect of the ballast will be to enable the vessel to float 12 inches to 14 inches lighter when it is dropped than she would do before. In other words, although her armored deck is only 4 feet 6 inches above the water, and this height only is exposed to the enemy's fire, the surplus buoyancy, on account of the ballast, will be the same as though the armored deck stood 5 feet 6 inches or 5 feet 8 inches above the water line.

It will be obvious that this quantity of ballast, amounting to about one-ninth of the whole weight of the ship, cannot be carried about for nothing. It adds to the work the engines have to do, and a greater expenditure of engine power for a given speed will be required to enable the ship to drag the ballast about with her. The additional engine power that will be required to drive the *Polyphemus* at full speed, after adding the ballast, will necessitate an increased coal consumption of 9 to 10 per cent., and a corresponding reduction in coal endurance. It will hardly be considered necessary to carry about all

this dead weight in time of peace, and it will be a question for practical consideration whether the carrying of it about in time of war at a cost of reduction in speed, or in coal endurance—and this in a ship whose coal supply is very small for her power—will be compensated for by the armored deck being 4 feet 6 inches out of water, instead of 5 feet 6 inches.

The *Polyphemus* is more or less of an experimental character, and the building of future ships possessing some or all of her characteristics, will depend upon the results of her trials. She is not likely to create a great revolution in war shipbuilding, or to show that guns are unnecessary in a fleet. Indeed, it must be evident that there are many operations, such as the bombardment of fortifications, which could only be carried out by ships armed with guns. The question respecting the *Polyphemus* is not whether such vessels as she are to supersede gun vessels, but whether she may not serve the more humble, though very useful, purpose of starting a type of war ships that will be valuable auxiliaries in action. Mr. Ward Hunt, on the occasion before referred to, spoke of her as follows:

"This vessel, must of course, to a certain extent, be regarded as an experiment, and, even supposing it to be a success, I could not propose it to the House as being likely to supersede all other kinds of fighting ships, but only as a useful adjunct to a fleet in case of war. Probably it would not be desirable that she should be kept at sea for a long period at a time, but I venture to think she will prove a very formidable weapon, and, if she should be a success, she may perhaps be regarded as a sort of rival to those monster ships with tremendous armor that we hear spoken of as likely to be built in some foreign ports."

The *Polyphemus* was commenced in September, 1878, and is already far advanced, being entirely framed and plated, except at the extreme ends. Great progress is being made with her, and she could be got ready for launching in a very few months.—*London Times.*

Absorption of Hydrogen by Nickel.—M. Raoult has shown that porous nickel absorbs hydrogen when it is employed as the magnetic electrode in the decomposition of acidulated water.—*Proc. Soc. Franc. de Physique.*

NEW SUBMARINE CABLES.

After a period of stagnation extending over five years, there is again a revival of submarine cable enterprise; and cable electricians, who have been for that time deprived of their legitimate occupation, are now experiencing brighter prospects. There are no less than four distinct cables in course of being manufactured or laid; and others are projected. Last year the Eastern Telegraph Company completed the duplication of their Oriental lines from England to Bombay, and the Eastern Extension Telegraph Company, which prolongs the Eastern Company's system to Australia *via* Madras, Penang on the Malay Peninsula, and the East Indian Islands, are at present engaged in duplicating their lines also, a work which has been somewhat delayed, however, by their giving up 1400 miles of ready-made cable to form a portion of the cable to the Cape. The latter important line of communication is, of course, the chief cable operation now in hand, and we regret to see that there was some delay in the furtherance of the work, for the steamship *Kangaroo*, belonging to the Telegraph Construction and Maintenance Company, who are the contractors, although she arrived at Durban on May 21, 1879, with the Natal to Zanzibar section on board, had not begun to lay her cargo until June 17th. For some unaccountable reason a valuable month was lost by this cable steamer, although the need for the cable is, or at least was, so urgent. It is to be hoped that the difficulties in the way, whether due to bad weather or faults in the core, or to the rumored refusal of a subsidy by the colony of Natal, on the ground that the terminus ought to be within the Natal borders, have by this time been smoothed away, and that the line is now laid as far as Zanzibar. The second section is on its way out in the steamship *Seine*, and the steamship *Calabria* carried the remainder.

The agreement between the Eastern Telegraph Company and the government requires that the entire cable shall be capable of transmitting fourteen words a minute, and that the company shall, save in cases of *force majeure*, have the portion of the cable betwen Durban and Zanzibar opened for traffic by July 31st, and the entire line by the last day of 1879. The company agrees to keep a repairing ship, properly equipped, in the Red Sea or Indian Ocean for maintaining

the line. All government messages, whether imperial or colonial, are to have priority to all other traffic, at one-half the rate charged to the general public. The public rate is not to exceed 5s. per word between Durban and Aden; 4s. per word between Zanzibar and Aden; and between Aden and London, by the Eastern Telegraph Company's lines, the sum of 3s. 9d. per word. The total charge for a message from Durban to London must not therefore exceed 12s. 9d. per word. Her Majesty's Treasury may nominate an official director on the boards of the companies owning and working the line, to whom every information must at all times be afforded. On the completion of the line between Natal and Zanzibar, the treasury agrees to pay, during a term of twenty years, an annual subsidy of 17,500*l.*, and a like sum on completion of the line between Zanzibar and Aden, provided always that the line is kept in good working order. In case of war, rebellion or other emergency, the Imperial Government or the government of any British colony or possession, duly authorized by Her Majesty's Government so to do, may take possession of the cables, stations, offices and apparatus on the line, and keep possession of them for as long as they may think fit. For this privilege the government agrees to make a reasonable compensation to the company. The last clause provides that the agreement shall not be binding until it has been approved by a vote of the House of Commons. It is, we think, a wise foresight on the part of the government to arrange for taking possession of the lines themselves if need be, and the day is perhaps not far distant when not only the Cape cable but also the Indian cables of the Eastern Telegraph Company may become the property of the nation.

The second great cable enterprise, now in progress, is the Pouyier-Quertier scheme for two Atlantic cables from Brest to New York. This project was ostensibly put forth as designed to gratify the *amour propre* of the French people, who wished to have Atlantic cables of their own. But the offer of the Anglo-American Company to sell or lease them a cable was declined and the original plan adhered to. It is probable that the ultimate aim of the new company is to compete with the existing Atlantic cables for English as well as Continental traffic, a supposition which is borne out by the fact that the Scilly Islands off the coast of Cornwall have been chosen as an intermediate landing point for the cable. The new cables are being made by Messrs. Siemens Brothers at their Charlton works, and the steamship *Faraday*,

which laid the direct United States cable, has already submerged the Brest to Scilly section of the first line.

Within the limits of Europe itself a short cable made by Mr. Henley for the Russian Government was recently laid across the Caspian Sea, and there is now in process of manufacture a new German-Norwegian cable, intended to connect Scandinavia direct with Germany. Hitherto the latter power has been obliged to send all her telegrams to Norway through Denmark and Sweden, a course which was irksome to her, owing to the uneasy political relations which have for a long time existed between her and Denmark. The agreement entered into between the representatives of the German Empire and the governments of Norway and Sweden stipulates that Germany shall lay the new cable at her own cost. It is to be a three-wired line, and will be laid from Romoe, an island off the west coast of Schleswig and the Norwegian peninsula, at a point near Arendal. At the latter place it will be connected to the whole Scandinavian telegraph system. The cable is estimated to cost 95,000*l.* and will belong to Germany, who will also repair it. All telegrams from Norway to Germany are to pass through the new line, and also three-fifths of the Norwegian traffic with other countries (excepting Russia, England and Denmark), unless the new route should prove more expensive than the old ones. It is obvious that this arrangement will materially reduce the inland telegraph revenue of Denmark, for hitherto all the German-Norwegian traffic has passed through that country. The new cable is, we believe, being manufactured by Messrs. Siemens and Halske, of Berlin, and it is expected to be laid some time in August.

Besides these actual performances, there are at least two projects for new submarine cables afloat; one by the American Cable Company to lay a line from New York to Flores, an island of the Azores, with one connecting line from Flores to France, England and Holland, and another from Flores to Fayal (Azores), San Miguel and Lisbon. These will comprise 7300 miles of line, if they are ever executed. The other scheme is for the long-talked-of Pacific Ocean cable from some point on the western coast of the United States to the Sandwich Islands and thence to Japan and China. Mr. Cyrus W. Field, the cable veteran of Atlantic fame, is the chief promoter of this undertaking, and he was in England for the purpose of investigating the subject of making and laying the cable in question. He holds, it appears, an exclusive concession from the government of the Sandwich

Islands for such a cable; a fact which was first announced at the recent Cable Jubilee or celebration of the twenty-fifth anniversary of the organization of the first Atlantic Cable Company. Similar concessions have yet to be obtained from China and Japan, but as the Celestials are now awake to the advantages of the telegraph, it is expected that these will be obtained without difficulty. A company will be formed to carry out this work and Mr. Field has, we understand, agreed to contribute $100,000 as a subscription to the capital stock. The establishment of this cable would complete the telegraphic circuit of the world, and we can only hope that Mr. Field will be as successful in carrying the electric wire across the Pacific Ocean as he was in spanning the Atlantic.—*Engineering.*

RECTANGULAR BORING MACHINE.

At one of the recent meetings of the Franklin Institute Dr. Robert Grimshaw exhibited a sample of the work done by J. Hall's rectangular hole boring machine. As this mechanical paradox attracted considerable attention at the Paris Exhibition, the readers of the JOURNAL will be interested in a brief explanation of it.

The drill has for section an equilateral triangle. The tool-holder of a special shape, having a screw at the upper portion, then a rectangular section; then a round section of a given diameter; then another section of the same shape, but of a greater diameter. There is a hollow rectangular sleeve, somewhat larger and narrower than the rectangular section. A slight horizontal and vertical movement can be thus obtained. This sleeve varies in size and in amount of play according to the work to be done. When the tool is in position it is guided by a steel plate, which has a hole corresponding to the one we wish to bore.

In turning, the tool occupies various positions, the cutting portion following the exterior contour of the rectangular guiding plate. If a pressure is exerted upon the tool, the boring will commence producing, as desired, a rectangular hole. If any portion of the tool be considered during its rotation, it will be found that the loci of the same represent most interesting curves of the third and fourth orders.

PETROLEUM AS FUEL.

A method of using petroleum as fuel for steam boilers has been recently tried at Pittsburg with, it is said, complete success, and as oil can be had anywhere in the region of the wells for about 70 cents a barrel, the company who hold the patent believe that the invention will be readily taken up, especially by the owners of steamboats. It resembles in its principal features many of the forms we have previously described—air, steam and oil-spray being injected into a suitable fire-box. The spray is said to be immediately converted into inflammable gas, becoming a pure, bright, powerful flame, devoid of smoke and producing intense heat. To accomplish this result extremely simple machinery is used. A small hole is drilled into the iron front of the fire-box, and into this passes a tube which branches as it leaves this point into two pipes. One of these connects with the boiler itself, and the other with the receptacle containing crude oil. At the junction of these pipes there is an aperture for the admission of atmospheric air. Valves of peculiar construction regulate the quantity of steam or oil admitted to the furnace. This is all the machinery required, but its operation, according to the Pittsburg *Telegraph*, is wonderfully complete and remarkably successful. The little steamer *Billy Collins* was selected by Mr. Campbell for the test and was fired up at 9 A. M. A preliminary blaze of wood under the boiler raised the small quantity of steam necessary to start the burner into operation. The oil valve was opened a trifle, the steam valve ditto. The petroleum trickled into the feed pipe, was caught up by the steam, and both plunged into the depths of the fire-box, a mass of many-tongued, roaring, brilliant flame. As the pressure of steam increased, this flame grew in fury and intense heat, roaring through the entire length of the boiler with a sound like the coming of a thunderstorm. The needle of the steam gauge climbed rapidly up the dial, and in twenty minutes the safety valve blew off at 120 pounds pressure. It was a remarkable sight. Here was a boat puffing through the water with no sign of smoke from her chimneys, no speck of soot in flues or fire-box, no fireman, no opening of furnace doors, no dirt, no coal going in, and no clinkers or ashes to be seen anywhere. A turn of the hand regulated the terrible flame that seemed trying to overpower the limits

of the furnace, and another turn of the hand brought the fire down to a quiet little flame, a foot or two long. During the forenoon occupied by the test, about 20 gallons of crude oil were consumed, and Mr. Campbell's estimate was, that with oil one dollar per barrel, this fuel was equivalent to coal at six cents [quantity not stated] in heat-producing value, other things being equal. But other things are not equal by any means, and everything is in favor of oil as against coal. The labor and expense of "firing up" is dispensed with, and the engineer can regulate the flame as he does the steam in his engines. The danger from sparks and flying cinders is entirely done away with. The space occupied by oil, as compared to an equal value of coal, is very much less, and this much is gained for cargo. Further, the wear and tear upon boilers, grate bars, etc., is infinitely less, and, it seems scarcely necessary to add, the comfort of passengers is greatly enhanced by the absolute freedom from dirt of all kinds. To the Western boatman this method of steam-producing is full of interest. "Coal is coal" on Western rivers. Here is a fuel that seems provided by nature especially for use on craft where every atom of carrying space is valuable. To ocean-going steamers this device must prove of extraordinary interest. A tank of oil situated at a remote end of the ship would hold fuel sufficient for a double trip, and supplant the great coal bunkers with their attendant dirt. Space prevents even a glance at the possibilities of this burner on the ocean. To railroad men this burner is full of promise also. A locomotive boiler, with its many tubes, would be pierced in every part with this wonderful oil flame, and the benefits arising from the entire absence of sparks, cinders and smoke are simply incalculable.

Taming Horses by Electricity.—The Paris Omnibus Company employs a full electric current as an effective check upon all restive horses. The current is excited by a small Clarke induction machine, the wires communicating with the bit through the reins. In case of any resistance or viciousness on the part of the horse, the driver simply presses a button, and the moment the current is felt the will of the animal seems to be completely annihilated, so that he submits at once. The effect seems to be a simple numbness and uneasiness, rather than an actual pain, and the method is generally regarded as much more humane than whipping, curb-bits and other common appliances. —*La Nature.* C.

ARTIFICIAL DIAMONDS.

The production and manufacture of imitation precious stones, always considerable, has been rapidly increasing in France of late years, and at the present time, owing to the perfection at which the art has arrived, the demand greatly exceeds the supply. The chief seat of the manufacture is supposed to be Paris, but this is a popular error. The dealers carry on business in that city, but the artificial stones are manufactured in the mountains of the Jura, Franche-Comté, the communes of St. Claude, Septmoncel, la Meure, les Molunes, and the surrounding districts. The inhabitants, men, women and children, are entirely engaged in the production of these stones, and have been so for generations past. They particularly excel in the cutting of artificial diamonds, the process of which we shall explain in detail in a future article. At the present time this species of industry has developed into a great resource for the inhabitants of the above districts, and they positively neglect the cultivation of the land in its favor. Certain of them undertake the cutting of real stones, but in this, as a whole, they cannot approach the careful workmanship and execution of the Paris lapidaries.

At the present day a special composition possessing a considerable refractive power serves exclusively as a base for artificial diamonds and other precious stones. This product is called *strass*. It differs from glass by the presence of about fifty per cent. of oxide of lead comprised in its elements. The name is derived from that of a workman named Strass, who, in the last century (about 1772), first directed attention to the composition, and is credited with being the inventor.

At the present time strass consists of the following:

Silica, ...	38·2
Oxide of lead, ...	50·0
Potash, ...	7·8
Alumina, borax, arsenious acid, .	traces.

The ingredients and substances composing modern strass are doubtless the same as those employed in the Middle Ages, and it is probable that their proportions differ but slightly. But modern chemistry provides the manufacturers of our day with products of perfect purity,

and the *modus operandi* has become greatly simplified. The procedure of the early makers was prodigiously complicated. They were nevertheless aware of the fact, confirmed by modern experience, that the longer the fusion was continued the more beautiful the strass became. When the substance is produced perfectly pure it serves to imitate all precious stones. It is remelted and intimately incorporated with substances with metallic bases, generally oxides, which by their combination with the elements of the strass communicate to it divers colors. Imitation sapphires are produced by 1000 parts of strass and 25 of oxide of cobalt. Emeralds, by 1000 parts of strass, 8 of oxide of copper, and 0·2 of oxide of chromium. *Diamonds*, being colorless, pure strass alone is employed, cut in the form of a brilliant or rose.

Artificial diamonds composed of mere strass alone were however at the best most unsatisfactory imitations. They were soft, white and glassy, and quickly thrown aside by purchasers as failures. Quite recently, however, one of the descendants of the Franche-Comté lapidaries, after many years of patient investigation, has brought about a revolution in the manufacture of imitation diamonds. He substitutes a preparation of gold for the oxide of lead in the composition of the strass, and further, the stones when cut are subjected to a chemical process by which the refractive power is made equal to that of real diamonds of the purest water. These perfect stones attracted great attention, and were much commented upon in the Paris Exhibition, where they were exposed side by side and in the same cases with real diamonds of great price. They are now being introduced to the English public under the name of *diamants brillants*. The samples which have been submitted to our inspection are certainly far nearer in their resemblance to real stones than anything of the kind which has previously come under our notice.—*English Mechanic.*

HEATING BY RADIATION.

By Lewis W. Leeds.

That the earth should be surrounded by and be driven through a space of intense cold, and that all the sensation we term heat should come through millions of miles of this intense cold before reaching us, ought to give us some hints of the natural conditions under which

our existence becomes possible. The whole warmth upon the surface of the earth is received by radiation from the sun. The air is warmed by coming in contact with the warmed earth. The air warmed by this contact with the heated earth rises, and the colder air from above tumbles down to take its place. This forms the great natural ventilation or circulation of air over the surface of the earth which sustains all life.

We should endeavor to imitate this in our artificial arrangements for heating buildings. As all solid objects at the surface of the earth are warmer, on the average, than the air, our bodies are made to conform to that condition. They are, therefore, much better sustained while inhaling the natural cold air than when inhaling warmed air.

The idea of attempting to warm our buildings by overheating the fresh air supply has been a most unfortunate one for the American people. It is a very unnatural one, and it is impossible to make our systems conform to it. It has been adhered to and pushed with characteristic American perseverance, but the third and fourth generations submitted to such premature stewing seem no fonder of it than their great-grandfathers. They only become less in stature and weaker in mind, and if continuously fed on such air would probably act much like the Irishman's horses, just as they had become able to endure such worthless, straw-like stuff, they would die.

For healthfulness the open fire most nearly imitates the radiant heat of the sun. The air, warmed by immediate contact with the fire, is carried up the chimney. It is not thrown into the room to be breathed.

As the radiation from the fire passes through the pure air without warming that air, it follows that the rays of heat are thrown across the room to the opposite walls and partially warms them, and warms any persons in the immediate range of that radiation. It follows, therefore, that the persons in a room may be comfortably warmed by the direct rays of an open fire or other hot body while being surrounded with and inhaling cold invigorating air. This is much more wholesome and more agreeable to our system, because more natural, than when surrounded by that artificial condition produced by all our warm air contrivances, when the air is hotter than the solid objects in the room. All these air-warming contrivances which we have been introducing so extensively are unnatural and incorrect, and the sooner we abandon them and adopt the natural system of warming by radiation, as is done by the sun, the better it will be for the health, strength and prosperity of the nation.—*Plumber and Sanitary Engineer.*

Potential Energy of Liquid Surfaces.—In 1876, G. Van der Mensbrugghe demonstrated the two following propositions:

1. If the upper free layer of a liquid mass undergoes an expansion, it becomes cooler; if, on the contrary, it contracts, it becomes warmer.

2. In each case there are developed in the mass thermo-electric currents, with intensities inversely proportioned to the mass, and directly proportioned to the surface variations.

He applied these propositions to the explanation of the movements on the surfaces of soap-bubbles, the alternating movements of liquid layers on other liquids, the occasional extraordinary production of heat in a solid when moistened by a liquid, the thermo-electric currents developed by variations of extent in the surface of separation between two liquids, the enormous electric discharges in storms, the maintenance in a liquid state of the little drops which form clouds and mists in a freezing atmosphere, the exceptional phenomena presented by some alloys near their limits of greatest density, the intense heat which is required to detach a volatile liquid from a porous surface, the phenomena of ebullition observed in Donny's classical experiments, Hansten's relation between meteorological perturbations and magnetic variations, the movements of bubbles of air in levels and vapor-bubbles in the cavities of minerals, and Savart's phenomena in liquid sheets. In a recent paper he has extended the application of his formulas to the loss of heat in a jet of vapor, the increasing energy of waves, the formation of bars at the mouths of rivers, and the motion of the Gulf Stream. His explanations are all very ingenious, and many of them are confirmed by satisfactory experiments.—*Bull. de l'Acad. Roy. de Belgique.* C.

SCIENTIFIC SPECIALTIES.

MORPHOLOGISCHES JAHRBUCH, v. 5, part 1. A. Rauber, on the occurrence of budding among the vertebrata.

JOURNAL DE PHYSIQUE, June. Cornu, spectroscope for ultra-violet. Crova, spectrometry of high temperatures. H. Becquerel, magnetic rotatory power of gases. Bichat, do. of liquids and their vapors.

ANTHROPOLOGICAL INSTITUTE, London, June 24. W. H. Flower, osteology of the Andamar Islanders.

PHYSICAL SOCIETY, June 21. Unwin, friction of fluids on solid substances against which they rub. June 28. Adams, new measuring polariscope. Conroy, distribution of heat in the spectrum.

NATURE, July 17. Hollway, use of sulphides as fuel for rapid oxidation. July 24. Galton, results of experiments on friction at high velocities, showing effect of brakes on railway trains. Moebius, on the Eozöon question. July 31. Carpenter, on the Eozöon. Ferrier, review of Calderwood on brain and mind.

ROYAL SOCIETY, June 19. Roberts, new tide-prediction.

ACCADEMIA DEI LINCEI, June 1. Tommaso-Crudelis and Kubs, nature of the specific agent which produces fevers from malaria. Villari, thermic and galvanometric laws of electric sparks from condensers.

QUARTERLY JOURNAL OF MICROSCOPICAL SCIENCE, July. Lewis. microphytes in blood, and their relation to disease.

JOURNAL OF ANATOMY AND PHYSIOLOGY, July. Fleming, physiology of the Turkish bath, and effects of hot dry air upon man. Hamilton, on the process of healing.

RIVISTA SCIENTIFICO-INDUSTRIALE, Nos. 11—13. Ferrini, electric conducting power of carbons. Palazi, constitution of fogs and clouds. Roster, new method to determine the melting point of organic substances.

VIENNA ACADEMY, May 15. Lippich, electro-megnetic rotation of the plane of polarization of light in air.

PHILOSOPHICAL MAGAZINE, August. Rowland, on Ayrton and Perry's new theory of Earth's magnetism. Smyth, spectroscopy of C and carbo-hydrogen. Preston, consistency of cyclical changes with the tendency to temperature-equilibrium.

AMER. JOUR. OF SCIENCE AND ARTS, August. Upham, terminal moraines of the N. A. ice-sheet. Cutter, microphotography with Tolles' $\frac{1}{75}$ inch objective. Kimball, magnetic strains in iron. Hillyard, loess of the Mississippi valley and the Aertian hypothesis. Peirce, on Faye's method of swinging pendulums for the determination of gravity. Hodges, on the size of molecules.

AMERICAN NATURALIST, August. Gatschet, adjectives of color in Indian languages. Upham, formation of Cape Cod.

RECENTLY PUBLISHED.

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